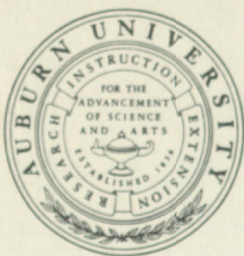


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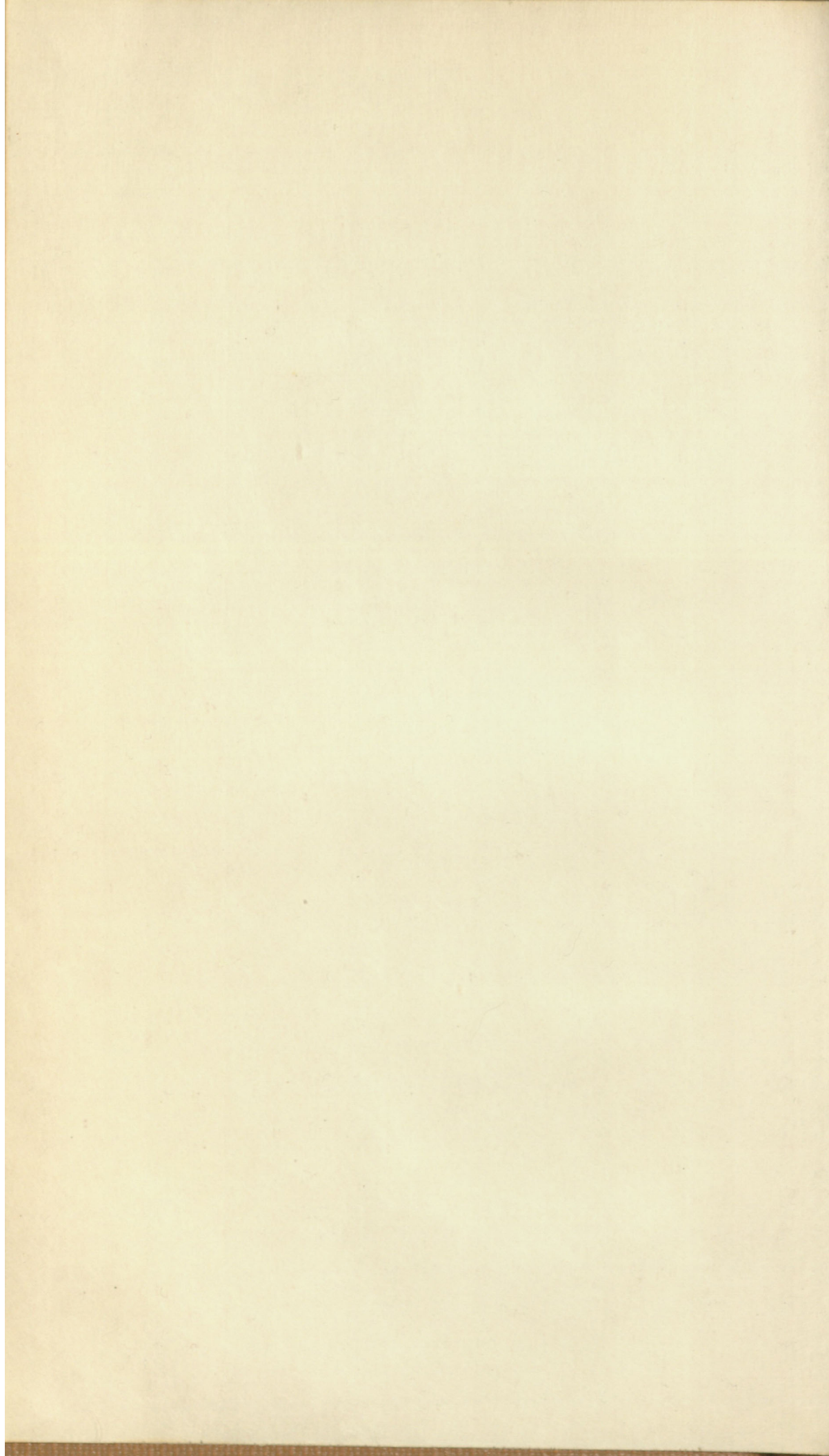
DEPARTMENT OF AGRICULTURE

REPORT NO. 11

STATISTICS OF THE IMPROVED
PRODUCTION OF ALABAMA
FOR 1917

COMPILED FROM THE REPORTS OF THE
COUNTY COMMISSIONERS





GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

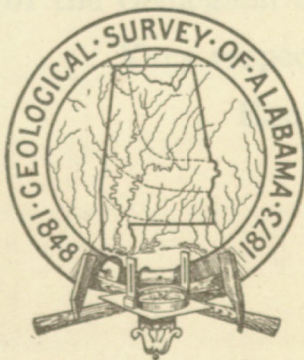
BULLETIN NO. 21

It STATISTICS OF THE MINERAL " PRODUCTION OF ALABAMA FOR 1917

COMPILED FROM THE MINERAL RESOURCES OF THE
UNITED STATES

By

WALTER B. JONES



UNIVERSITY, ALABAMA

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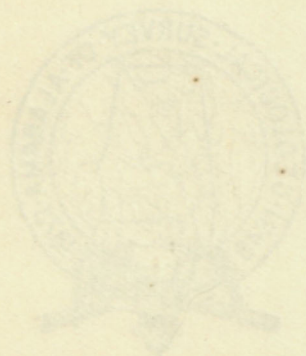
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BULLETIN NO. 21

STATISTICS OF THE MINERAL
PRODUCTION OF ALABAMA
FOR 1917

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LETTER OF TRANSMITTAL

UNIVERSITY, ALA., February, 1920.

HON. THOMAS E. KILBY,
Governor of Alabama,
Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1917 with the request that it be printed as Bulletin No. 21 of the Geological Survey of Alabama.

Very respectfully,

EUGENE A. SMITH,
State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.....State Geologist
William F. Prouty, Ph. D.....Chief Assistant
Robert S. Hodges.....Chemist
Herbert H. Smith.....Curator of Museum
Roland M. Harper, Ph. D.....Botanist
A. T. Donoho.....Secretary
George N. Brewer.....Field Assistant

RIVER GAGE HEIGHT OBSERVERS.

Conecuh River at Beck, Ala.

A. W. Lambert.....Route F. Andalusia, Ala.

Coosa River at Riverside, Ala.

J. E. Whitehead.....Riverside, Ala.

Tallapoosa River at Sturdevant, Ala.

A. L. Stowe.....Alexander City, Ala.

Big Bear River near Red Bay, Ala.

Ed Bullen.....Red Bay, Ala.

Observations are made every day by these observers of the gage readings at the several stations. From these records when extended through sufficient time, the calculation of available horse power to be obtained from the different streams is made.

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PREFACE

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it to our present purposes. In each case credit is given to the author.

INTRODUCTION

EUGENE ALLEN SMITH.

AN INSPECTION of the subjoined tables will show that there has been in 1917 an increase both in quantity and value of the mineral products of the State, with the exception of gravel, cement, bauxite, mineral waters and sandstone.

Following the plan set out by Mr. E. W. Parker in 1913, and continued by the Alabama Survey, we pass in review the production in 1916 and 1917 of Alabama minerals, and their immediate derived products, taking them up somewhat in the order of their commercial importance.

COAL.—Alabama's production of coal in 1917 was 20,068,074 short tons, valued at \$45,616,992, an increase of 10.9 per cent. in the quantity, and of 83.5 per cent. in value as compared with 1916. As in 1916, the value of coal products in Alabama in 1917 was more than three-fifths of the total mineral output of the State.

COKE.—The coke production of Alabama increased from 4,298,417 short tons, valued at \$15,019,139 in 1916 to 4,892,589 short tons, valued at \$28,394,212 in 1917, an increase in the value of 88.8 per cent.

IRON ORE.—In 1917 there was an increase of 4.3 per cent. in the total quantity of iron ore production in the State as compared with 1916, 4.9 per cent in the quantity of hematite and 1.8 per cent in the quantity of brown ore.

PIG IRON.—In the quantity of pig iron marketed in Alabama in 1917, there was an increase in the quantity from 1916, of 299,128 gross tons, or 11 per cent, and of \$25,315,054, or 65 per cent. in the value. The value of the iron ore production, and not the value of the pig iron, is used in making up the total value of the mineral products of the State.

The total value of the mineral production of Alabama, excluding the value of pig iron and coke, and including the value of the iron ores and the coal, was in 1917 \$65,423,224, compared with \$40,973,430, in 1916, of which, as already stated, more than three-fifths is represented by the products of the coal mines. More than one-fourth

of the total value was contributed by the iron mines. The increase in 1917 from 1915 was \$35,815,747 or 121.5 per cent.

The principal coal producing counties are Jefferson, Walker, Bibb, Tuscaloosa, and St. Clair, in the order named. The principal iron ore counties are Jefferson, Tuscaloosa, Franklin and Etowah. The combined value of the pig iron and coke made in Alabama in 1917 was \$92,703,926. These values are not included in the total as they are represented in the value of the iron ore and coal produced.

CLAY WORKING INDUSTRIES.—These industries yielded products in 1917 valued at \$2,106,516 as against \$1,520,301 in 1916, an increase of \$586,215 or 38.56 per cent. This does not include the value of the raw clay sold, which in 1917 amounted to \$84,763, an increase in 1917 of 66 per cent.

The center of the clay-working industry is Jefferson County, and Birmingham furnished the principal market. Vitrified, common, and fire brick, represent a value of \$1,377,770, or 66.3 per cent. of the total value, while the total output of the brick yards makes up 71.5 per cent. of the total value of the clay products of the State. All the fire brick is reported from Jefferson, Baldwin and Calhoun counties, and all the vitrified brick is from Jefferson and St. Clair counties. Clay pits for the manufacture of common brick have been opened in one or more places in thirty-two counties.

The pottery products in 1917 consisted of stone-ware, yellow and Rockingham ware, and red earthen ware, including turpentine cups, and represented a value of \$18,731, a decrease of \$4,074 over 1916, or 17.8 per cent.

STONE.—The quarry products, exclusive of marble, the greater part of which is limestone, valued in 1917 at \$1,296,006, an increase from 1916 of \$357,452, or 38.1 per cent. This increase was mainly in the limestone used for flux and in lesser degree in limestone for building purposes.

Over 75 per cent. of the total value of the stone production in 1917 is that of limestone. Its most important uses are for furnace flux, concrete, riprap and for building purposes. The production of marble in 1917 was

practically the same as that in 1916. The figures of production can not be given because of the limited number of producers.

Marble holds second place in the value of the quarry products. Beautiful white marble occurring in Coosa and Talladega Counties, is extensively used for building work, (both inside and outside). A black marble which gives promise of future development, has been prospected near Anniston and near Piedmont.

The reader is referred to the body of this bulletin, under Stone, for further details concerning especially the building stone and marble industries.

CEMENT.—The cement production of Alabama in 1917 amounted to \$1,329,833 barrels, valued at \$1,494,879 as against 1,442,475 barrels, valued at \$1,410,104 in 1916. This was a decrease of 7.8 per cent. in quantity and an increase of 6.0 per cent. in value.

LIME.—The lime production is not included in that of the limestone. It amounted in 1917 to 66,744 short tons, a decrease from the 1916 production of 780 short tons, or 1.2 per cent. The value of the product is \$383,211, an increase from 1916 of \$70,680, or 22.6 per cent.

GRAPHITE.—The Alabama graphite is of the crystalline variety, and the value of the product in 1917 was \$719,575 as against \$492,407 in 1916, an increase of 46.1 per cent. The Alabama product for 1917 was 65 per cent. of the total value for the crystalline graphite for the United States. The great increase in the production and value of the Alabama graphite since 1915, and the installing of a number of new plants in 1916 make it probable that the Alabama production in coming years will represent even a larger proportion of the total United States value.

MINOR PRODUCTS.—Alabama produces a small quantity of barytes, bauxite, mill stones, mineral waters, sand and gravel, quartz, and pyrite.

In the following table there is a comparison of the mineral output in Alabama in the years 1916 and 1917. As stated above, the total does not include the value of the pig iron or that of the coke, but it does include the value of the coal made into coke, and of the iron ore sold or used in making pig iron.

Mineral production of Alabama in 1916 and 1917.

PRODUCT	1916				1917			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quant'y.	Value.	Quantity	Value.	Quantity.	Value.
Coal, short tons	18,086,197	\$24,859,831			20,068,074	\$45,616,992		
Coke, short tons			4,298,417	\$15,019,139			4,892,589	\$28,394,212
Iron ore, long tons	6,801,839	10,843,231			7,101,586	13,049,535		
Pig iron, long tons			2,672,498	38,994,660			2,971,626	64,309,714
Limestone, exclusive of marble								
Cement, barrels		917,559				1,278,908		
Lime, short tons			1,442,475	1,410,104			1,329,833	1,494,879
Marble			67,524	312,531			66,744	383,211
Clay products								*
Graphite, pounds				1,520,301				2,106,516
Sand and gravel, short tons	5,226,940	492,407			6,223,095	719,575		
Clay, short tons	726,650	184,216			476,678	222,011		
Pyrite, long tons	41,479	51,053			58,667	84,763		
Bauxite, long tons	*	*			*	*		
Sandstone, including ganister					8,281	52,317		
Barytes, long tons	7,631	20,995				17,098		
Mineral waters, gallons sold	103,944	12,174			1,976	8,858		
Gold, fine ounces, Troy			418	8,650	56,270	5,509		
Mica, sheet, pounds			14,132	4,955				
Mica, scrap, short tons			65	660				
Manganese ore, long tons	*	*						
Natural gas		*						
Miscellaneous		307,565				383,052		
Total†		\$40,973,430				\$65,423,224		

*Included in Miscellaneous. †Includes raw and derived, except coke and pig iron.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1917

ABRASIVES.

EUGENE A. SMITH.

ALABAMA'S production of abrasives is at present limited to a small number of millstones (chasers*) of Pennsylvanian age, quarried and made at Dutton, Jackson County; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigating and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see.

BARYTES.

(Condensed from Mineral Resources of the United States.)

JAMES M. HILL.

THE barytes marketed from Alabama in 1917 was 1,976 short tons as compared with 7,631 short tons in 1916, a decrease of 74 per cent. Mines near Angel, in Calhoun County, produced a large part of the barytes sold in 1917.

*Chasers are larger than the regular millstones. They are used for heavier work, such as grinding quartz, feldspar, barytes, etc., and they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 50 to 84 inches, and are as much as 22 inches in thickness. These chasers are run on pans paved with roughly cubical blocks of the conglomerate, with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks the material placed in the pan is ground to powder.

though several hundred tons were produced near Wilsonville, Shelby County, and Leeds, Jefferson County.

The deposits near Jacksonville, Calhoun County; Vincent, Harper, and Wilsonville, Shelby County; and Leeds, Jefferson County, were under development, and a considerable production was made from the mine in Jefferson County, at which a steam-driven hoisting plant and log washer is operated. The mine is about 5 miles south of Leeds in the flat valley bottom of Little Cahaba River. The Chickamauga (Pelham) limestones (Ordovician), in which the valley is cut,* strike north-northeast and dip southeast at steep angles. The mining has exposed the very rough surface of the underlying blue-gray limestone, in which barite in irregular masses replaces the lime and magnesium carbonates. The barytes is mined from the red residual clay overlying the limestone and some large masses of barytes have been found, though the great bulk of the barytes ranges from 1 to 4 inches in size and is of high grade.

From 1 to 3 miles north of Angle station and about 12 miles northwest of Jacksonville, Calhoun County, there are a series of barytes deposits on which a little development has been done. These deposits lie at the base of white quartzite ridge in red residual clay that is derived from blue-gray magnesian limestone, whose age has not been definitely determined but which is probably Knox dolomite.

In the vicinity of Vincent, Harpersville, and Wilsonville, eastern Shelby County, there are small irregular masses of barytes in the red residual clays derived from limestone of Beekmantown age.† Shipments have been made from several small pockets, and it is reported that at a number of places indications point to larger bodies.

Details concerning the manufacture of ground barytes, of lithopone, and of barium chemicals and their uses are given in Bulletin No. 19 of the Alabama Geological Survey, and in the Mineral Resources of the United States for 1916.

E. A. S.

*Butts, Charles, U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), 1910.

†Butts, Charles, U. S. Geol. Survey Geol. Atlas, Montevallo-Columbiana folio (in preparation).

BAUXITE AND ALUMINUM.

By JAMES M. HILL.†

BAUXITE.

DOMESTIC PRODUCTION.

THE quantity of bauxite marketed in the United States in 1917 was 568,690 long tons, which had a value at the mines of \$3,119,058, an increase over the production of 1916 of about 34 per cent in quantity and about 36 per cent in value. The production from the Georgia, Alabama, and Tennessee field in 1917 was 62,134 long tons, an increase of about 26 per cent; and the Arkansas production of 506,556 long tons showed an increase of approximately 35 per cent.

Bauxite produced and consumed in the United States, 1913-1917.

YEAR.	DOMESTIC PRODUCTION					
	Georgia, Alabama, and Tennessee		Arkansas.		Total	
	Quantity (long tons)	Value.	Quantity (long tons)	Value.	Quantity (long tons)	Value.
1913.....	40,370	\$150,710	169,871	\$846,988	210,241	\$997,698
1914.....	24,071	92,508	195,247	976,686	219,318	1,069,194
1915.....	28,245	144,345	268,796	1,370,489	297,041	1,514,834
1916.....	49,190	284,810	375,910	2,011,590	425,100	2,296,400
1917.....	62,134	395,051	506,556	2,724,007	568,690	3,119,058

YEAR	Exports‡		Imports		Domestic consumption	
	Quantity (long tons)	Value	Quantity (long tons)	Value	Quantity (long tons)	Value
1913.....	21,456	\$85,746	*	*	231,697	\$1,083,444
1914.....	24,844	96,500	‡5,374	\$240,084	238,788	925,610
1915.....	3,420	17,107	16,082	717,186	284,379	814,755
1916.....	30	87	18,032	987,454	407,098	1,309,033
1917.....	7,760	29,433	21,791	1,323,936	554,659	1,824,565

†The statistical data in this report were prepared by Miss H. M. Gaylord, of the United States Geological Survey.

‡Includes bauxite concentrates.

*Included in "All other articles."

‡From July 1, 1914, includes bauxite concentrates.

Apparently the producers of aluminum consumed about 375,000 tons, the makers of chemicals about 82,000 tons, makers of abrasives about 110,000 tons, and the makers of refractories about 2,400 tons of bauxite in 1917.

As will be seen by the table, though the domestic consumption of bauxite in 1917 also increased 36 per cent over the consumption in 1916, the domestic deposits were able to supply nearly the whole demand. The larger exports were apparently made to Canadian aluminum and abrasive makers.

MARKET AND PRICES.

The market for bauxite in the United State is east of Mississippi River, and the largest consumers are located at or near the cities of East St. Louis and Aurora, Ill.; Detroit, Mich.; Cincinnati, Ohio; Knoxville, Tenn.; Philadelphia and Erie, Pa.; Niagara Falls and New York City, N. Y.; and Boston, Mass. Recently a number of municipal and industrial waterworks have installed small plants for the manufacture of aluminum sulphate for local use in purification of water. A complete list of those known to the United States Geological Survey to be users of bauxite follows:

USERS OF BAUXITE.

Aluminum Co. of America, Pittsburgh, Pa.
Booth Chemical Co., P. O. Box 203, Elizabeth, N. J.
Carborundum Co., Niagara Falls, N. Y.
Charles Lennig & Co. (Inc.), 112 South Front Street, Philadelphia, Pa.
Charles Taylor Sons Co., Cincinnati, Ohio.
Columbus Waterworks, R. D. 5, Columbus, Ohio.
Cumberland Waterworks, R. D. 3, Cumberland, Md.
Detroit Chemical Works, 238 Junction Avenue, Detroit, Mich.
E. I. du Pont de Nemours Powder Co., Wilmington, Del.
Erie Chemical Works, 31 Union Square W., New York, N. Y.
Exolon Co., 156 Sixth Street, Cambridge, Mass.
General Abrasives Co., Niagara Falls, N. Y.
General Refractories Co., Trinity Building, New York, N. Y.
Harbison-Walker Refractories Co., Pittsburg, Pa.
Jerecki Chemical Co., St. Bernard Station, Cincinnati, Ohio.
Laclede-Christy Clay Products Co., St. Louis, Mo.
Masillon Stone & Fire Brick Co., Masillon, Ohio.
Merrimac Chemical Co., 33 Broad Street, Boston, Mass.

Metropolitan Water District of Omaha, Omaha, Nebr. (R. B. Howell, general manager.)
 Montclair Waterworks, Little Falls, N. J.
 Norton Co., Worcester, Mass. (also Niagara Falls, N. Y.)
 Pennsylvania Salt Manufacturing Co., Widener Building, Philadelphia, Pa.
 Springfield Waterworks, Springfield, Mass.
 Superior Chemical Co., Joliet, Ill.

Bauxite is graded according to its chemical composition and is sold to the consuming industries on the basis of analysis. Apparently low content of silica and titanium is essential to the aluminum industry, but the content of iron may be fairly high, though bauxites low in iron and titanium are preferred by the makers of alum and aluminum sulphate. Makers of abrasives appear to be able to use bauxites of lower grade and containing larger proportions of silica and iron than are permissible in bauxite for other uses, but most abrasives are made from bauxites low in silica and iron. The bauxite used for refractories must apparently be fairly low in iron.

The prices received for bauxite in 1917, as reported by producers, ranged from \$4.75 to \$10.50 a long ton; the average price paid for the whole of the domestic bauxite sold in the country was \$5.48 a long ton at the shipping point.

OCCURRENCE AND CHARACTER OF BAUXITE IN THE UNITED STATES.

The known commercial bauxite deposits of the United States are in Calhoun, Cherokee, and DeKalb counties, Ala.; Pulaski and Saline counties, Ark.; Bartow, Floyd, Meriwether, Sumter, and Wilkinson counties, Ga.; and Carter and Hamilton counties, Tenn. A brief description of the geology of the domestic deposits was given in the report for 1916,* and detailed descriptions of the deposits in central Georgia have been published by the Georgia Geological Survey.†

The bauxite from all localities in the United States, though it may vary in chemical composition, is on the

*Hill, J. M., Bauxite and aluminum in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 161-165, 1917.

†Shearer, H. K., A report on the bauxite and fuller's earth of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 31, 1917.

whole similar in general appearance, with the exception of the "granitic bauxite" of the Arkansas field. The greater part of the American bauxite appears to be made up of rounded pebble-like bodies set in a fine-grained matrix, which may also consist of small rounded particles or may be as fine grained as the finest clay. The pebble or pisolite form is so general that it is the conspicuous characteristic of American bauxite.

There is only one way to determine the value of bauxite, and that is by chemical analysis, which should show total silica, alumina, titanium oxide, iron oxide, and water. Bauxite of commercial grade should carry at least 52 per cent of alumina.

A few characteristics that indicate in a general way the quality of bauxite may be mentioned, though none of them are to be depended on. In general, bauxite of fair grade will not show the marks of a hammer when it is hit a glancing blow, though some bauxite has been shipped which can be cut with the hammer. Good bauxite that has been dried either in the open or in kilns when thrown on a hard floor has a distinct rattle, which bauxite clay does not have. The pistolites of the lighter-colored bauxites of the central Georgia field have a peculiar brownish-buff color and look something like horn or flint; they ordinarily can not be broken or marked with the finger nail in bauxites of good grade.

Some measure of the relative quality of dried bauxite can be had by grinding a sample in an agate mortar for half a minute. A bauxite of good grade will be found hard to grind and will stick to the mortar with such tenacity that it will have to be scoured out; a poor bauxite or bauxitic clay will grind much more easily and will stick very little, if at all; and clay or kaolin grinds with ease and does not stick to the mortar. Similar results are found if the sample is rubbed on glass; the glass will not be scratched by even high-grade bauxite.

NOTES ON THE UNITED STATES BAUXITE MINES.

Alabama.—During 1917 three companies were operating in the Alabama field—the E. I. du Pont de Nemours Co., at the Snider mine, north of Piedmont, but in Chero-

kee county; the Republic Mining & Manufacturing Co., near Rock Run, Cherokee County; and the Consolidated Mining Co., near Fort Payne, DeKalb County.

The production of bauxite from Alabama in 1917 showed an increase of about 44 per cent over the production in 1916. The output was used for the manufacture of alumina chemicals to the extent of 53 per cent; abrasive, 44 per cent; and refractories, 3 per cent.

Arkansas.—The American Bauxite Co., Globe Bauxite Co., E. I. du Pont de Nemours Co., and Republic Mining & Manufacturing Co. mined bauxite from deposits in Saline and Pulaski counties, Ark. The largest production was made from the deposits near Bauxite, Saline County.

The production from Arkansas in 1917 showed an increase of 35 per cent over the production in 1916, and it is believed that should the demand arise the Arkansas deposits are capable of much greater output and contain considerable reserves. The bauxite mined from the Arkansas deposits is of high grade, as is shown by the fact that more than 71 per cent of the output in 1917 was used for the manufacture of aluminum, nearly 19 per cent from abrasives, 9 per cent for chemicals, and 1 per cent for refractories.

Georgia.—The total production of bauxite from Georgia in 1917 was approximately 52,000 tons, an increase of about 31 per cent over the production in 1916. Wilkinson County produced the largest quantity, Sumter County was second, Floyd County third, Bartow County fourth, and Meriwether County fifth in rank of output.

Georgia bauxite appears to be more suitable for the manufacture of alumina chemicals than for other purposes. The output in 1917 was distributed as follows: 59 per cent for alumina chemicals, 21 per cent for aluminum, and 20 per cent for abrasives.

In Bartow and Floyd counties in 1917 five companies were mining bauxite from deposits near Adairsville, Cave Springs, Hall, Hermitage, Linwood, and Pinson. The total quantity of bauxite shipped from the north Georgia area was approximately 15,000 tons, of which approximately 53 per cent was used for alumina chemicals, 33 per cent for abrasives, and 14 per cent for aluminum.

There was a small production of bauxite from the deposits near Warm Springs, in Meriwether County, which was used for alumina chemicals. It is reported that an eastward extension of these peculiar deposits has been found and will be developed during 1918.

In the central Georgia field three operators reported production of bauxite from deposits in Sumter County and five operators from deposits in Wilkinson County. The production of bauxite from this area was approximately 37,000 long tons, of which 61 per cent was used for alumina chemicals, 23 per cent for aluminum, and 16 per cent for abrasives.

Tennessee.—The bauxite deposits on Missionary Ridge were reported idle during 1917. A small output was made at the mines near Elizabethton, Carter County, but car shortage hampered operations. A new deposit of bauxite has been discovered near Hixon, 15 miles north of Chattanooga.

ALUMINUM.

DOMESTIC PRODUCTION AND CONSUMPTION.

The value of primary aluminum produced in the United States in 1917 was \$45,882,000, an increase of 35 per cent over the value of the output in 1916. This increase is due in part to the increased price and in part to the greater output of primary aluminum in 1917. No estimate can be made at this time (March, 1918) of the recoveries of secondary aluminum during 1917, but the data at hand, though incomplete, indicate that the recoveries will not be smaller than in 1916. Information concerning this phase of the aluminum industry will be found in the chapter of Mineral Resources on secondary metals in 1917, which is now in preparation.

Value of aluminum produced and consumed in the United States, 1913-1917.

YEAR	Domestic production		Imports [¶]	Exports	Apparent consumption
	Primary metal	Secondary metal [†]			
1913	\$9,450,000	\$2,199,480	\$3,845,611	\$966,094	\$14,528,997
1914	10,080,000	1,673,140	2,801,211	1,546,510	13,007,841
1915	16,280,000	5,802,100	1,808,193	3,682,117	20,208,176
1916	33,900,000	23,430,200	1,785,870	15,417,134	43,698,936
1917	45,882,000	*	56,880	14,586,468	†31,352,412

[†]Value based on average open market price, as quoted by Eng. and Min. Jour.

[¶]Imports for consumption, figures from Department of Commerce reports. Includes aluminum in crude form, leaf, sheets, plates, bars, strips, wire, rods, and all manufactures of; table, kitchen, and hospital ware.

^{||}Exports of aluminum and manufactures of; figures from Department of Commerce reports.

*No statistics available.

†This includes primary metal alone in 1917.

MARKET AND PRICE OF ALUMINUM.

In the United States the quoted prices for primary or "virgin" aluminum ranged from 62 cents a pound, in January, to 37 cents a pound, in October, a price which was maintained to the end of the year. The average for the year was 51.59 cents a pound, as compared with 60.71 cents in 1916. These prices are for small lots and immediate delivery, offered in the open market, and do not represent the price received by the single producer of primary aluminum in this country.

Prices of aluminum, 1913-1917, in cents per pound.[†]

YEAR	Average open market price, small lots	Contract price
1913	23.64	*
1914	18.63	*
1915	33.98	20-31
1916	60.71	31-37
1917	51.59	31-37

[†]Eng. and Min. Jour. quotations in annual review numbers.

*No figures published, but it seems reasonable to believe that contracts were made on approximately the same basis as for 1912.

On March 5, 1918, announcement was made in the papers of Washington, D. C., that the President had fixed the maximum base price of virgin aluminum, 98-99 per

cent pure, for lots of 50 tons or over, at 32 cents a pound. This price is subject to revision June 1, 1918.

Secondary aluminum, 98-99 per cent pure, recovered from scrap materials, sold for 56.40 cents a pound at the beginning of 1917. Its price followed the decline of virgin metal to a low of 35 cents a pound in the latter part of October, a price which was maintained to the end of 1917.

NOTES ON THE ALUMINUM INDUSTRY.

The Aluminum Co. of America is now operating four electrolytic plants in the United States at which aluminum is made—at Massena and Niagara Falls, N. Y., Maryville, Tenn., and Badin, N. C. The Badin plant made its initial run in 1916, but was not producing much aluminum until August, 1917. Additional power is under development for the Maryville plant, which will further increase the producing capacity of the United States.

The British Aluminum Co. is reported* to be enlarging its aluminum works at Kinlochleven, in Scotland. On February 28, 1917,† the ministry of munitions took under control the secondary aluminum industry, establishing prices for purchase and resale of various grades of remelted materials containing aluminum and issuing rules for the makers and refiners of such materials, called "aluminum scrap and swaf." It will be recalled that the primary aluminum industry was placed under control December 7, 1915.

USES OF ALUMINUM.

The uses of aluminum have been changed somewhat by war conditions. Pleasure-car automobile makers have restricted the use of metal in bodies and parts of various kinds. Four makers of pleasure cars are making aluminum-alloy engines. Much aluminum is being used for military equipment of all kinds. It is believed that the domestic producers will be able to supply the demand for 1918,‡ but uncertainty as to what the demand will be makes predictions dangerous.

*Eng. and Min. Jour., vol. 103, p. 880, May 19, 1917.

†Min. Jour. (London), vol. 116, p. 129, Mar. 3, 1917.

‡Aluminum industry in 1917: Metal Industry, vol. 16, p. 21, January, 1918.

OTHER BAUXITE PRODUCTS.

Nearly 65 per cent of the domestic output of bauxite in 1917 went into aluminum, manufacturers of aluminum salts used nearly 13 per cent, 19 per cent was consumed in the manufacture of bauxite abrasives, and 3 per cent was used by makers of "high-alumina refractories," also called bauxite brick.

Within the last two years many foreign and domestic patents have been issued relating to the use of bauxite in the fixation of nitrogen, the manufacture of aluminum salts, and the fabrication of abrasives and refractories. Copies of these patents may be obtained from the United States Patent Office, Washington, D. C.

ALUMINUM SALTS.

The principal aluminum salts made in the United States are alumina, alums, usually ammonium and sodium alums, aluminum sulphate, and aluminum chloride. Alumina is largely consumed in the manufacture of aluminum, and no figures of domestic production are available for publication.

Alums of various qualities are produced at 9 plants in the eastern United States, the total production of alum in 1917 being 19,714 short tons, valued at \$1,017,083, a decrease of approximately 28 per cent in quantity and of 14 per cent in value from the production in 1916. The average price reported by makers of alums was \$51.60 a short ton. The wholesale market quotations ranged from 4 to $5\frac{1}{8}$ cents a pound, or \$80 to \$102 a short ton. The quotations on lump alum were fairly constant at 4 to $4\frac{1}{4}$ cents up to May, when an increase to $4\frac{1}{2}$ to 5 cents was made. This price remained steady till November, when it dropped to 4 to $4\frac{1}{2}$ cents. Ground alum at the first of the year was quoted at $4\frac{1}{8}$ to $4\frac{3}{8}$ cents, but prices rose to $4\frac{5}{8}$ to $5\frac{1}{8}$ cents about the middle of May and remained stationary until the last of September, when they began to drop, and reached $4\frac{1}{10}$ to 5 cents at the end of 1917.

Aluminum sulphate is made at 24 plants, 7 of which are at municipal or industrial waterworks, which consume their entire output. The total quantity of aluminum

sulphate produced in the United States in 1917 was 178,738 short tons, of which 4,947 short tons did not enter the market but was used for water purification at the place of manufacture. The quantity of domestic aluminum sulphate which entered the market, 173,791 short tons, was greater than the quantity in 1916 by approximately 18 per cent, and the total domestic production increased about 16 per cent. The price reported by makers of aluminum sulphate for the 1917 output averaged \$32.15 a short ton. Market quotations for low-grade aluminum sulphate ranged from a low of 2 cents to a high of 4 cents a pound, or \$40 to \$80 a short ton. Low-grade aluminum sulphate was quoted at 2 to 2½ cents a pound until October, when quotations rose to 2 to 3½ cents, but fell to 2 to 3 cents during the second week of November, and closed at 1¾ to 2¼ cents a pound at the end of the year.

Aluminum chloride is used for various purposes, among which may be mentioned the refining of mineral oils. This salt was produced at 3 plants in 1917, and the total output reported to the Geological Survey was 4,702 short tons, valued at \$311,900, or approximately \$66 a short ton. Market quotations on aluminum chloride remained stationary throughout the year at 4 to 4 1/10 cents a pound, or \$80 to \$82 a short ton.

Alum and aluminum sulphate produced in the United States and aluminum salts imported, 1913-1917.

YEAR	PRODUCTION						IMPORTS*	
	Alum			Aluminum sulphate			Quantity (short tons)	Value
	Quantity (short tons)	Value	Price per ton	Quantity (short tons)	Value	Price per ton		
1913	9,605	\$312,822	\$32.57	157,749	\$2,977,708	\$18.88	2,702	\$66,549
1914	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	73,028
1915	24,915	699,256	28.07	169,153	3,224,495	19.06	1,408	34,320
1916	27,257	1,177,881	43.21	153,860	4,410,741	28.67	1,247	68,660
1917	19,714	1,017,083	51.60	178,738	5,746,427	32.15	507	39,088

*Includes alumina, aluminum hydrate or refined bauxite, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground.

BAUXITE ABRASIVES.

Bauxite abrasives sold under various trade names, such as alundum, aloxite, exolon, and lionite, are made by fusing bauxite in an electric furnace. These products are sold in the form of powders, colth, grinding stones, and wheels of various shapes for a multitude of uses.

The total marketed production of artificial abrasives made from domestic bauxite in 1917 was 48,460 short tons, valued at approximately \$6,970,000, or about \$144 a short ton. This is an increase over the production in 1916 of 58 per cent in quantity and of 200 per cent in value. The average value is deceptive, however, in that the prices received for the product depend on many factors, among which hardness, size of grain, degree of finishing, and many others may be mentioned.

HIGH-ALUMINA REFRACTORIES.

There are two classes of high-alumina refractories now on the market. What are commonly called bauxite brick are made by mixing various proportions of calcined bauxite or high-alumina clay with a bonding material such as fire clay, sodium silicate, or lime. Refractories of this character are being made by the Laclede Christy Clay Products Co., the Harbison Walker Refractories Co., Charles Taylor & Sons, and the Masillon Stone & Fire Brick Co. Not all the refractories made by these companies are sold as bauxite brick, and in fact some do not contain bauxite. The other class of high-alumina refractories consists of those made by the electric fusing of bauxite. These are manufactured by the companies that make artificial abrasives.

The use of high-alumina refractories seems to be expanding, particularly in the construction of copper, iron, and lead furnaces and of cement kilns. No figures are now (March, 1918) available to show the production of high-alumina refractories, though it is known that at least 2,313 long tons of bauxite was consumed in making refractories.

CEMENT.

EUGENE A. SMITH.

PORTLAND CEMENT.

RESOURCES.

ALABAMA contains large supplies of limestone, chalk, clay and shale well adapted to Portland cement manufacture, and widely distributed throughout the State. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location was immensely increased with the opening of the Panama Canal for cement plants located in Alabama are more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the State lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our State beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent lime carbonate and 25 per cent of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufac-

ture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Coosa Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same company makes use of residual clays overlying and derived from the weathering of the Selma Chalk. During 1915, and since, there was no production from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the State, furnishes excellent material for Portland cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone.

PUZZOLAN CEMENT.

During the past seven years only one establishment in Alabama, the Southern Cement Company, North Birmingham, has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

Owing to the fact that there was in Alabama in 1917 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of the two indus-

tries in order to avoid publishing figures which were given to the Survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and Puzzolan cement sent to market in Alabama in 1917, was 1,329,833 barrels, valued at \$1,494,879, as compared with 1,442,475 barrels, valued at \$1,410,104 in 1916; a decrease of 112,642 barrels, or 7.81 per cent, and an increase in value of \$84,775 or 6.01 per cent.

Below in tabular form are given the foregoing figures:

Quantity and value of Portland and Puzzolan cement, marketed in Alabama in 1916 and 1917.

	No. of Producers	Quantity (Bbls.)	Value
1916 _____	3	1,442,475	\$1,410,104
1917 _____	3	1,329,833	1,494,879
Increase or decrease _____	—	112,642	+ 84,775
Per cent of increase or decrease _____	—	7.8	+ 6.0

RECOVERY OF POTASH FROM PORTLAND CEMENT MATERIALS.

It has been noticed that the flue dust in a cement plant often contains notable percentage of potash, and efforts have been made to utilize this dust in the extraction of potash. Flue dust from the Standard Cement Plant shows $2\frac{1}{2}$ per cent and above potash, and it is in contemplation to utilize this, and the suggestion is also made to use feldspar in the manufacture. Up to the present time, however, there has been no commercial production of any potash from this source.

CLAY AND CLAY PRODUCTS.

CLAY.

JEFFERSON MIDDLETON AND EUGENE A. SMITH.

CLAY available for the manufacture of clay products is one of the most widely distributed of our minerals. Hence there are clay-working plants scattered over every State and Territory in the Union. Miners of the low-grade clays are usually also the manufacturers, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer buys and does not mine the clay he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The total amount of clay mined in Alabama and sold as such in 1917 was 58,667 short tons valued at \$84,763. This was an increase in quantity of 17,188 short tons or 41.4 per cent, and of \$33,710 or 66 per cent in value as compared with 1916.

Below is a table giving the production and value of clay mined and sold in Alabama from 1908 to 1917 inclusive, and a comparison of the production of 1916 and 1917:

Production of clay in Alabama from 1908 to 1917 inclusive, and a comparison of the production in 1916 and 1917.

YEAR	FIRE CLAY		MISCELLANEOUS CLAY		TOTAL	
	Quantity Short Tons	Value.	Quantity Short Tons	Value.	Quantity Short Tons	Value
1908	68,289	\$48,983	24,000	\$12,000	92,289	\$60,983
1909	45,137	35,345	18,271	5,587	63,408	40,932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,203	29,909			35,203	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
1913	49,901	53,269	*	*	49,901	53,419
1914	27,973	34,607			27,973	34,607
1915	31,520	34,882	*	*	31,870	35,232
1916	40,235	50,618	1,244	435	41,479	51,053
1917	41,951	67,674			58,667	84,763
Increase	1,716	17,056			17,188	33,710
Percentage	4.2	33.7			41.4	66.

*Not divulged but included in total.

In 1916 the average value of the fire clay of Alabama was \$1.26 per short ton, and the value of the fire clay production of the State was 1.37 per cent of the total value of the United States production. In 1917 the average value of the Alabama fire clay was \$1.61 per short ton, and the value of the Alabama product was 1.2 per cent of the total value of the fire clay produced in the United States.

CLAY PRODUCTS.

The State of Alabama is rich in clays of many kinds, yet its rank as a clay working State is low, being twenty-fifth in 1916. It advanced, however, to nineteenth in 1917. Its clay products in that year reported by 53 operators were valued at \$2,106,516—brick and tile, \$2,087,785; pottery, \$18,731—an increase over 1916 of \$586,215, or more than 38.56 per cent. Alabama ranked ninth in quantity and in value of vitrified brick, or block. Its principal clay product was common brick, valued at \$557,920, or 26.7 per cent of the State total, an increase over 1916 value of \$60,474. The quantity of common brick

marketed in 1917 was 81,574,000 brick, a decrease of 4,091,000 brick.

Fire brick, including silica fire brick was Alabama's clay product of second value, a total of 19,815,000, valued at \$502,936.

Vitrified brick was third, with 21,319,000 brick, valued at \$316,914, a decrease from 1916 of 3,824,000 in quantity, and an increase of \$5,597 in value.

Jefferson County was the principal clay-working county, nearly all of the fire and vitrified brick or block produced in the State coming from this county. The principal common-brick-producing counties, named in the order of the value of their output were Jefferson, Montgomery and Talladega.

In tabular form these statistics are given as follows:

Clay products of Alabama, 1912-1917.

PRODUCT.	1912	1913	1914	1915	1916	1917
Brick:						
Common—						
Quantity	136,989,000	130,923,000	110,731,000	70,681,000	85,655,000	81,574,000
Value	\$759,409	\$730,148	\$638,666	\$382,092	\$497,446	\$557,920
Average per M.	\$5.54	\$5.58	\$5.77	\$5.41	\$5.81	\$6.84
Vitrified:						
Quantity	26,480,000	24,183,000	18,679,000	29,018,000	25,143,000	21,319,000
Value	\$353,303	\$361,722	\$248,525	\$374,387	\$311,317	\$316,914
Average per M.	\$13.34	\$14.96	\$13.31	\$12.90	\$12.38	\$14.87
Front—						
Quantity	10,629,000	*	*	5,815,000	6,968,000	*
Value	\$132,033	*	*	\$58,212	\$77,470	*
Average per M.	\$12.42	\$15.29	\$11.42	\$10.01	\$11.12	\$12.17
Fancy, value	\$240,434		\$167,021	\$145,535	\$278,749	\$502,936
Fire, value	\$5,465	\$10,802	\$6,838	\$9,330	*	\$17,261
Drain tile, value	*	*	*	*	*	*
Sewer pipe, value	*	*	*	\$62,114	\$80,523	\$106,700
Fireproofing, value						
Tile, not drain, value						
Pottery:						
Red earthenware, including turpentine cups, value	\$10,990	\$11,164	\$4,800	\$6,741	\$13,551	\$6,060
Stoneware and yellow and Rockingham ware, value	\$11,223	\$8,994	\$11,742	\$8,556	\$9,254	\$12,671
Miscellaneous, † value	\$422,322	\$968,751	\$496,431	\$146,055	\$251,991	\$488,054
Total value	\$1,935,179	\$2,091,581	\$1,574,023	\$1,193,022	\$1,520,301	\$2,106,516
Number of active firms reporting	74	68	70	65	57	53
Rank of State	17	16	20	24	25	19

*Included in "Miscellaneous." †Miscellaneous includes drain tile, sewer pipe, stove lining and silica brick.

Value of the clay products of Alabama in 1916 and 1917, with increase or decrease.

	BRICK AND TILE	POTTERY	TOTAL
1916	\$1,497,496	\$22,805	\$1,520,301
1917	2,087,785	18,731	2,106,516
Increase or decrease:			
Value	590,289 —	4,074	586,215
Per cent	+ 39.4 —	17.8 +	38.8

Pottery products of Alabama are of minor importance, constituting less than 1 per cent of the value of clay products. Production was reported in 1917 by eleven firms. The output was valued at \$18,731, a decrease of \$4,074, or 17.8 per cent as compared with 1916. The products consisted of stone ware and yellow and Rockingham ware, and red earthen ware, including turpentine cups, etc. The latter represents a very notable proportion of the total product. The rank of Alabama in the pottery industry in 1917 was 17.

Comparison of pottery products in 1916 and 1917.

KIND	1916	1917	Increase or decrease	Percentage
Red earthenware	\$13,551	\$6,060 —	\$7,491 —	55.5
Stoneware and Rockingham ware.....	9,254	12,671 +	3,417 +	37.0
Total	\$22,805	18,731 —	4,074 —	17.8

*Including turpentine cups, vases, etc.

COAL.

E. W. PARKER AND C. E. LESHER.

INTRODUCTORY.

THE great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production is the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 85 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby and Bibb counties. There are many workable beds, and the total quantity of coal in the basin

is large. The production is something over 15 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, DeKalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable. So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given at 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 17,678,522 tons in 1913, since which time there has been a decrease, until 1916, when the maximum of 1913 was exceeded, as may be seen in table below.

PRODUCTION.

The statistics of production in Alabama from 1840 to the close of 1917 are shown in the following table:

Production of coal in Alabama from 1840 to 1917 in short tons.

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantity
1840.....	946	1860.....	10,200	1880.....	323,972	1900.....	8,394,275
1841.....	1,000	1861.....	10,000	1881.....	420,000	1901.....	9,099,052
1842.....	1,000	1862.....	12,500	1882.....	896,000	1902.....	10,354,570
1843.....	1,200	1863.....	15,000	1883.....	1,568,000	1903.....	11,654,324
1844.....	1,200	1864.....	15,000	1884.....	2,240,000	1904.....	11,262,046
1845.....	1,500	1865.....	12,000	1885.....	2,492,000	1905.....	11,866,069
1846.....	1,500	1866.....	12,000	1886.....	1,800,000	1906.....	13,107,963
1847.....	2,000	1867.....	10,000	1887.....	1,950,000	1907.....	14,250,454
1848.....	2,000	1868.....	10,000	1888.....	2,900,000	1908.....	11,604,593
1849.....	2,500	1869.....	10,000	1889.....	3,572,983	1909.....	13,703,450
1850.....	2,500	1870.....	11,000	1890.....	4,090,409	1910.....	16,111,462
1851.....	3,000	1871.....	15,000	1891.....	4,759,781	1911.....	15,021,421
1852.....	3,000	1872.....	16,800	1892.....	5,529,312	1912.....	16,100,600
1853.....	4,000	1873.....	44,800	1893.....	5,136,935	1913.....	17,678,522
1854.....	4,500	1874.....	50,400	1894.....	4,397,178	1914.....	15,593,422
1855.....	6,000	1875.....	67,200	1895.....	5,693,775	1915.....	14,927,937
1856.....	6,800	1876.....	112,000	1896.....	5,748,697	1916.....	18,086,197
1857.....	8,000	1877.....	196,000	1897.....	5,893,770	1917.....	20,068,074
1858.....	8,500	1878.....	224,000	1898.....	6,535,283		
1859.....	9,000	1879.....	280,000	1899.....	7,593,416	Total	323,629,988

Coal produced in Alabama, 1912-1917, and increase in 1917.

YEAR	Quantity (Net tons)	Value
1912	16,100,600	\$20,829,252
1913	17,687,522	23,083,724
1914	15,593,422	20,849,919
1915	14,927,937	19,066,043
1916	18,086,197	24,859,831
1917	20,068,074	45,616,992
Increase 1917	1,981,877	20,757,161
Percentage of increase, 1917	+11.	83.5

The production of coal in Alabama in 1917 was 20,068,074 tons, valued at \$45,616,992, an increase compared with 1916 of 1,981,877 tons, or 11 per cent, in quantity and of \$20,757,161, or 83 per cent, in value. This was the record year for production of coal in this State. The increase was shared by all counties except Etowah and Tuscaloosa. Jefferson County, with a gain of 600,000 tons, and Walker County, with 900,000 tons, showed the largest increase in quantity produced.

The demand for coal from the mines of Alabama exceeded the supply throughout the year. For the manufacture of coke to supply the demand of the iron and steel industry, 7,638,000 tons of coal were furnished, an increase over 1916 of 12 per cent, and the railroads of the South used in 1917 about 5,700,000 tons of coal from Alabama, an increase of about 1,100,000 tons, or 21 per cent over 1916, the two industries taking substantially all of the increase in production in the State, with the result that other commercial industries and domestic consumers suffered a real shortage, particularly in the more than ordinarily severe winter of 1917-18.

The average number of days worked in 1917 was 273, a record for the State and equaled by one other State, Virginia, and exceeded only by New Mexico in 1917. This represents about 90 per cent full time operation, if the number of working days in a year be taken as 304. The accompanying graphic representation (Fig. 24) of working conditions as compiled from weekly reports furnished by the majority of the operators from the last of July to the end of the year indicates approximately the same percentage in the last half of the year. That car shortage and transportation difficulties had but little effect on production and that the most important factor limiting output was labor trouble is shown by this diagram. Strikes in August and September and again in December resulted in a decrease in production and are shown clearly in figure 24. The record of strikes for the year shows 1,835 men affected for an average of 6 days, or 10,220 men-days lost. The loss, though but 0.1 per cent of the total men-days worked was, for Alabama, a non-union

State, very large. The record for 1916 was 920 men-days lost, and for 1915, 1,290 men-days lost.

The increase in production was affected by the greater number of days worked (from 262 in 1916 to 273 in 1917); for, although the number of men employed increased from 25,308 to 28,386, the efficiency of the labor as indicated by the average output per man per day fell from 2.73 tons in 1916 to 2.6 tons in 1917 and the average annual production per employee fell from 715 to 707, notwithstanding the greater number of active days. This is partly accounted for by the fact that of the total increase in men employed (3,078, or 12 per cent), more than half (1,606) were surface men. The increase in total number of men was 12 per cent, in underground employees 7 per cent, and in surface employees 42 per cent. The men working on the surface contribute only indirectly to production.

The average value of the coal produced in Alabama in 1917 was \$2.27 per ton, compared with \$1.39 in 1916, an increase that was shared by all producing counties. The average value of all shipments was \$2.19 per ton; of coal sold locally, \$2.01 per ton; of mine fuel \$2.08 per ton; and of coal made into coke at the mines, \$2.71 per ton.

STATISTICS OF MINERAL PRODUCTION, 1917. 37

Coal Produced in Alabama in 1916 and 1917.

1916

COUNTY.	Loaded at mines for shipment (net tons).	Sold to local trade and used by em- ployees (net tons)	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Under- ground.	Sur- face.	Total	
Bibb	1,384,205	12,281	97,370		1,493,856	2,142	411	2,553	255
Blount & Jackson	207,986	2,875	1,250		212,111	389	36	425	240
Etowah	154,474	2,163	1,964		158,601	281	54	335	269
Jefferson	7,428,469	303,661	268,133	1,834,606	9,834,869	10,869	1,793	12,662	275
Marion	68,083	6,021	6,054		80,158	180	41	221	215
St. Clair	765,485	3,403	23,282		792,170	787	110	897	250
Shelby	578,551	9,705	30,382		618,638	938	204	1,142	270
Tuscaloosa	272,307	8,859	59,270	600,360	940,796	1,042	240	1,282	293
Walker	3,540,791	40,744	99,506	250,982	3,932,023	4,739	955	5,694	235
Winston	22,005	410			22,415	86	11	97	143
Small mines		560			560				
	14,422,356	390,682	587,211	2,685,948	18,086,197	21,453	3,855	25,308	262

*Includes Jackson County.

Coal produced in Alabama in 1917.

1917

COUNTY.	Loaded at mines for shipment (net tons).	Sold to local trade and used by em- ployees (net tons)	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Under- ground.	Sur- face.	Total	
Bibb	1,514,154	12,358	98,111		1,624,623	1,999	547	2,546	277
Blount	257,159	3,700	5,870		266,729	423	122	545	206
Etowah	150,153	1,918	2,194		154,265	197	41	238	271
Jefferson	7,089,174	229,060	300,555	2,834,304	10,453,093	11,746	2,731	14,477	291
St. Clair	813,070	3,406	20,519		836,995	643	91	734	290
Shelby	731,082	6,847	43,929		781,858	1,161	309	1,470	256
Tuscaloosa	193,800	87,528	36,642	605,765	923,735	1,227	315	1,542	240
Walker	4,364,113	151,560	123,649	205,158	4,844,480	5,170	1,193	6,363	248
Winston	43,456	444			43,900	118	20	138	176
Other counties†	116,555	3,111	10,264		129,930	241	92	333	223
Small mines		8,466			8,466				
	15,272,716	508,398	641,733	3,645,227	20,068,074	22,925	5,461	28,386	273

†Includes Cullman, Jackson, and Marion counties.

Value of coal produced in Alabama in 1917.

COUNTY.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Bibb	\$3,669,103	\$31,561	\$224,880		\$3,925,544	\$2.42
Blount	659,832	9,300	16,748		685,880	2.57
Etowah	320,239	3,702	4,523		328,464	2.13
Jefferson	15,445,288	382,805	653,963	\$8,167,903	24,649,959	2.36
St. Clair	1,560,721	6,764	30,320		1,597,805	1.91
Shelby	2,038,669	19,034	119,532		2,177,235	2.78
Tuscaloosa	453,778	190,742	68,182	1,234,479	1,947,181	2.11
Walker	8,786,741	347,490	198,182	470,145	9,802,558	2.02
Winston	124,307	1,100			125,407	2.86
Other counties*	332,817	7,851	15,525		356,193	2.74
Small mines		20,766			20,766	2.45
	33,391,495	1,021,115	1,331,855	9,872,527	45,616,992	2.27
Average value per ton	2.19	2.01	2.08	2.71	2.27	

*Includes Cullman, Jackson, and Marion counties.

Coal produced in Alabama, 1913-1917, in net tons.

COUNTY.	1913	1914	1915	1916	1917	Increase or decrease, 1917.
Bibb	1,911,026	1,674,846	1,534,534	1,493,856	1,624,623	+130,767
Blount	178,958	150,384	165,739	†212,111	266,729	+ 54,618
Cullman, Jackson, and Marion	123,615	81,041	†68,890	†80,158	129,930	+ 49,772
Etowah	137,792	156,909	177,368	158,601	154,265	- 4,336
Jefferson	9,028,834	7,936,145	7,579,503	9,834,869	10,453,093	+618,224
St. Clair	890,379	752,588	774,058	792,170	836,995	+ 44,825
Shelby	497,569	498,914	589,412	618,638	781,858	+163,220
Tuscaloosa	917,305	858,899	787,586	940,796	923,735	- 17,061
Walker	3,967,263	3,450,185	3,221,955	3,932,023	4,844,480	+912,457
Winston	24,951	31,618	26,627	22,415	43,900	+ 21,485
Small mines	830	1,893	†2,265	560	8,466	+ 7,906
	17,678,522	15,593,422	14,927,937	18,086,197	20,068,074	+1,981,877
Total value	\$23,083,724	\$20,849,919	\$19,066,043	\$24,859,831	\$45,616,992	+\$20,757,161

†Includes Jackson county. ‡Marion county only.

LABOR STATISTICS.

Men employed in the coal mines of Alabama, 1917.

Underground	22,925
Surface	5,461
Total	28,386

Statistics of labor employed in coal mines of Alabama, 1908-1917.

YEAR	Number of days active.	Average Number Employed.
1908.....	222	19,197
1910.....	249	22,210
1911.....	227	22,707
1912.....	245	22,613
1913.....	255	24,552
1914.....	226	24,042
1915.....	223	22,591
1916.....	262	25,308
1917.....	273	28,386

*Average production per man compared with hours worked per day,
and average number of days worked 1910-1917.*

Year	8 hours		9 hours		10 hours		All others	Total	Days Worked	Average Tonnage	
	Mines	Men	Mines	Men	Mines	Men	Men	Men		Per Year	Per Day
1910.....	18	766	36	2,633	134	17,306	1,525	22,230	249	725	2.91
1911.....	15	550	50	5,345	102	12,628	4,184	22,707	227	662	2.92
1912.....	11	338	46	4,145	107	13,938	4,192	22,613	245	712	2.91
1913.....	13	420	36	2,496	135	18,185	3,451	24,552	255	720	2.82
1914.....	14	646	24	3,546	150	18,115	1,785	24,042	226	648	2.87
1915.....	13	369	44	4,402	133	17,109	711	22,591	223	661	2.96
1916.....	9	306	40	2,724	132	20,736	1,902	25,308	262	715	2.73
1917.....	38	3586	27	1,900	143	20,766	2,134	28,386	273	707	2.59

Strikes and Suspensions.

Statistics of labor strikes in the coal mines of Alabama in 1916 and 1917.

1916			1917		
Number of men on strike	Total days lost	Average number of days lost per man	Number of men on strike	Total days lost	Average number of days lost per man
300	920	3	1835	10220	6

MINING METHODS.

The term "mining method" as used here refers to the manner in which the coal is broken down in the mine and not to the system of mining, or by room and pillar or long wall. In the mine the coal is either blasted from a solid face—shot from the solid—as in hard-rock mining, or is shot loose or otherwise broken down after a preliminary cut into the coal has been made. This cut may be made by hand or machine. Underground methods are therefore classified as shot from the solid, mined by hand, and mined by machines. An increasing quantity of coal is being recovered each year by stripping the cover from the bed in open pits by steam shovels. The bed thus exposed is for the most part shattered by powder and shoveled into cars by hand, although in places it is picked up directly by small steam shovels.

Opposition to shooting from the solid has developed, because it is injurious to the mining property in that the unusual charges of powder weaken the roof and pillars, which increases the liability to falls of roofs and coal, the most prolific cause of fatal accidents to coal miners. Another objection to this method is that the heavy charges of powder required to blow down the coal where it has not been previously undercut or sheared cause the production of a very high proportion of fine coal and render the lump coal so friable that it disintegrates in handling and in transportation. With the growing use of mechanical stokers and of powdered coal the latter objection is

losing much of its force, but the danger attending the method has been in no wise diminished, and it is forbidden by law in some of the coal-mining states. There was a slight increase in the total output shot from the solid in 1916 compared with 1915.

Statistics of bituminous coal recovered from steam shovel pits, appear for the first time in 1916. One shovel only was active in Alabama in 1915.

Quantity and percentage of coal mined by different methods in Alabama in 1916 and 1917, in short tons.

YEAR	Mined by hand	Percentage	Shot off the solid	Percentage	Mined by machines	Percentage	From steam shovel pits	Percentage	Not reported	Percentage	Total production
1916	5,658,300	31.3	6,547,225	36.2	5,802,150	32.1	75,462	0.4	3,060	—	18,086,197
1917	5,340,112	26.6	8,419,146	42.0	6,062,744	30.1	231,217	1.2	14,855	0.1	20,068,074

Bituminous coal mined by machines in Alabama in 1916 and 1917.

YEAR	Number of machines in use	Number of tons mined by machines	Total tonnage of Alabama	Percentage of total product mined by machines
1916	320	5,802,150	18,086,197	32.1
1917	332	6,062,744	20,068,074	30.1

COAL-WASHING OPERATIONS.

Not all coal can be cleaned by hand picking. Some coal beds or parts of beds have layers or benches of slate and bone or contain more than the allowable quantity of sulphur in the form of iron pyrite so thoroughly mixed with the coal that crushing is necessary to free the coal from the refuse. To clear such coal washing is resorted to and the coal, being lighter than the refuse, is separated by currents of water. Coal is also cleaned in the dry state.

Alabama leads in the quantity of coal washed, almost 44 per cent of the total quantity, so treated in 1917, being from the State.

Coal washed at the mines in Alabama in 1916 and 1917, with quantity of washed coal and of refuse obtained from it, short tons.

YEAR	Quantity of coal washed	Quantity of cleaned coal	Quantity of refuse	Percentage of cleaned coal to total state output
1916	10,695,700	9,742,467	953,233	53.9
1917	12,714,868	11,408,051	1,306,817	56.8

AVERAGE VALUE OF ALABAMA COAL.

Average value per short ton for coal at the mines in Alabama since 1908.

1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
\$1.26	\$1.19	\$1.26	\$1.27	\$1.29	\$1.31	\$1.34	\$1.28	\$1.37	\$2.27

DISTRIBUTION AND CONSUMPTION.

C. E. LESHER.

OBJECT AND SCOPE OF REPORT.

THE object of this report is to furnish statistics showing the internal distribution of the coal produced in the United States, the principal purposes for which it is used, and the quantities consumed in each State. For 34 years the Geological Survey has collected and published the statistics of the production and value of coal, but this is the first comprehensive investigation made to show in

detail where the coal produced is consumed. The competition between the bituminous coal-producing districts in the United States for the domestic markets is as active as that between the coal-exporting nations of the world for the foreign markets. The extent and nature of the demand in the domestic markets are moreover of ever-present interest to our coal industry, because more than 95 per cent of the coal produced in the United States is used within the country.

The largest problem confronting the exploiters of a coal deposit is, of course, that of markets, and whoever produces or sells the coal must consider in a broad way the possible markets not only as to quantity but as to quality. For blacksmithing and for making coal gas, coals that have special chemical properties are required, and domestic users have established preferences based on both experience and prejudice. By far the largest part of the coal supplied to every market is used for raising steam, and the statistics of coal used for this purpose in any and every part of the country are therefore of primary interest to those who are engaged in the coal industry. The limitations of time and funds available for the work on this report have permitted only incidental consideration of the markets for bituminous coals of particular kinds. The distribution of coal from West Virginia, for instance, is shown for the State as a unit, though there is a great difference between the kinds of coal mined there and as great a difference between the markets reached by the coal.

The cost of mining, the largest element of which—the cost of labor—is now practically controlled either directly or indirectly by the labor unions, and the cost of transportation, regulated by the Government through the Interstate Commerce Commission, impose definite limitations upon the markets that may profitably be reached by any coal. It is fast becoming the rule that the deciding factor in the purchase of coal for most uses is its cost in terms of the work to be performed.

Statistics of the movement of coal to market are of particular interest to those who are considering railroad rates. The quantity of coal carried by the railroads is

larger than that of any other single commodity, and it is the coal traffic that has made possible the profitable operation of a number of important railroads. It is to the interest of the coal-carrying roads, within the limits of fair play, to keep in balance the movement from the competing fields. Here, again, data of the kind given in this report are needed as a basis of intelligent action.

The report of the Geological Survey on the distribution and consumption of coal in 1915, the first attempt to present such detailed statistics, was so generally well received and appeared to fill such a timely need that it was hoped to continue the statistics for succeeding years. The work of supplying the demand for statistics of coal and coke that followed the entrance of the United States into the war, in April, 1917, was so heavy that it precluded any attempt to compile data on distribution and consumption for 1916. The advent of the United States Fuel Administration, late in 1917, with its demand for statistical information, presented a special need and afforded a means of comprehensive study of the statistics of distribution for 1917. The particular need for these data by the Fuel Administration was connected with the proposed allotment of bituminous coal from producing districts to consuming States, and the zone system of distribution. The work of compilation was undertaken by the writer in his capacity of geologist in charge of coal statistics for the Geological Survey and director of the bureau of statistics of the Fuel Administration. The data originally compiled in the early months of 1918 have all been rechecked and are presented as nearly as possible in the form of the report for 1915.

Complete and absolutely accurate reports of distribution are impossible to obtain and any attempt to compile such statistics as this report contains must include estimates, but it is believed that these data in all important respects are accurate and that some of the shortcomings of the statistics for 1915 have been overcome.

Distribution of bituminous coal produced in Alabama, 1917, by DISTRIBUTION OF COAL PRODUCED IN ALABAMA IN 1917.

IN ITS output of coal Alabama is the most productive State in the South, and it is centrally located as regards the markets of the Southern States. In 1917 the Southern railroads used nearly 6,000,000 tons of Alabama coal, which is 28 per cent of the production in Alabama and nearly 20 per cent of the consumption by the railroads in the South. In addition to that taken by the railroads, more than 11,200,000 tons, or more than half the total output, was used in the State; 2,600,000 tons, or 13 per cent of the output, was shipped to other States; and 580,000 tons, or 3 per cent, went to tidewater for foreign and domestic cargo and bunker fuel. Of the coal shipped outside the State for commercial use the greater part, about 1,675,000 tons, reached the Mississippi Valley markets in Louisiana and Mississippi and in a less amount those in Missouri, Tennessee, and Arkansas. On the east, Georgia and Florida are the best consumers of Alabama coal.

Competition by coal from the fields to the north, particularly those of southern Illinois and western Kentucky, restricts the expansion of markets for coal from Alabama in the Mississippi Valley and at New Orleans. Similar competition on the east by coal from Virginia, Kentucky, and Tennessee meets coal from Alabama in the markets of the Carolinas and Georgia. The higher grades of Alabama coal are sent in small shipments to markets as distant as the Pacific coast. The tidewater business at southern Atlantic ports (except Hampton Roads) and at Gulf ports is not very large as compared with that at the northern ports, and in 1917 it was below normal. About 580,000 tons of coal from Alabama reached tidewater in 1917.

9.2

100.0

*Includes 2,127,000 tons shipped to benthic coke ovens.

Distribution of bituminous coal produced in Alabama, 1917, by routes and destination.

STATE	All-rail shipments.						Shipped to tidewater.		Total quantity (net tons)
	Used within the State		Shipped to other States		Used by railroads.				
	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	Quantity (net tons)	Percentage of production.	
Alabama	11,222,916	56	2,622,000	13	5,641,254	28	581,904	3	20,068,074

The greater part of the coal produced in Alabama is used within the State or is taken by railroads in the South. Shipments to neighboring states represented in 1917 only 13 per cent and shipments to tidewater only 3 per cent of the total output.

Distribution of coal mined in Alabama in 1917.

	Quantity (net tons)	Percentage of total
Used in Alabama:		
Used at mines for steam and heat	641,733	
Sold to local trade, not shipped	508,398	
Made into coke at the mines*	3,645,227	
Shipped to Alabama	6,427,558	
	11,222,916	55.9
Shipped to other States by rail:		
Arkansas	15,000	
Florida	115,000	
Georgia	585,000	
Louisiana	925,000	
Mississippi	750,000	
Missouri	7,000	
Tennessee	175,000	
Texas	50,000	
	2,622,000	13.1
Used by railroads, all-rail delivery	5,641,254	28.1
Shipped to tidewater	581,904	2.9
	20,068,074	100.0

*Includes 2,127,000 tons shipped to beehive coke ovens.

STATISTICS OF MINERAL PRODUCTION, 1917. 47

South Atlantic and Gulf ports.

Originating field	Cargo, foreign	Bunker		Total
		Foreign	Coastwise	
Alabama	49,896	378,101	153,907	581,904

CONSUMPTION.

Bituminous coal of domestic origin consumed in Alabama, 1917, in net tons.

(Railroad fuel and bunker fuel for ocean vessels not included in this table.)

STATE	Used at mines for steam and heat.	Used in manufac- ture of beehive coke.	Used in manufac- ture of by-product coke.	Used in manufac- ture of coal and gas.	Used by electrical utilities.	Used for domestic purposes.	Used for indus- trial purposes.	Total coal consumed.
Alabama	641,733	3,658,598	3,980,243	90,886	299,966	651,000	2,131,490	11,453,916

Coal consumed in Alabama in 1917, according to source.

(Exclusive of fuel for railroads and steamships.)

SOURCE	Quantity net tons
Alabama	11,222,916
Kentucky	150,000
Tennessee	66,000
Virginia	15,000
Total bituminous coal	11,453,916
Pennsylvania anthracite	1,084
Total	11,455,000

Shipments by rail and water.

RAILROAD	Tons
Alabama Central	74,464
Atlanta, Birmingham & Atlantic	185,297
Birmingham Southern	3,144,419
Central of Georgia	767,618
Illinois Central	116,864
Louisville & Nashville	3,555,390
Mary Lee	21,190

Mobile & Ohio	326,382
Nashville, Chattanooga & St. Louis	18,037
St. Louis-San Francisco	2,293,246
Seaboard Air Line	45,452
Southern	4,017,868
Thomas & Sayreton	476,467
Woodstock & Blocton	101,730
Woodward Iron Co. Railroad	60,347

WATER

Warrior River	67,945
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Grand total 15,272,716

COKE.

PRODUCTION AND CONSUMPTION.

The production of coke in Alabama in 1880, 1890, 1900 and annually from 1910 to 1917 is shown in the following tables:*

Statistics of the manufacture of coke in Alabama, 1880-1917.

YEAR	Establishments	OVENS		Coal used (short tons)	Yield of coal in coke (per cent)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens, per ton
		Built	Building					
1880	4	316	100	106,283	57.0	60,781	\$ 183,063	\$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,423	2.67
1910	43	10,132	340	5,272,322	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,593,594	2.75
1912	46	10,208	100	4,585,498	64.9	2,975,489	8,098,412	2.72
1913	46	10,284	20	5,218,323	63.6	3,323,664	9,627,170	2.90
1914	38	9,318	0	4,678,196	65.9	3,084,149	8,408,443	2.73
1915	38	9,318	0	4,695,938	65.4	3,071,811	8,545,555	2.78
1916	—	*9,549	97	6,794,100	57.9	4,298,417	15,019,137	3.45
1917	—	9,660	0	7,638,841	63.9	4,892,533	28,394,272	5.80

*Includes 300 Semet-Solvay, 487 Koppers, and 60 Wilputte ovens.

STATISTICS OF MINERAL PRODUCTION, 1917. 49

Comparison of the production and value of coke in Alabama in 1916 and 1917.

	Number of ovens	Coal charged (short tons)	Coke produced (short tons)	Total value of coke at ovens	Percentage of total U. S. value
1916	9,549	6,794,100	4,298,417	\$15,019,139	7.9
1917	9,660	7,638,841	4,892,589	21,394,212	8.8
Increase	11	844,741	594,172	13,375,133	
Percentage	0.1	12.4	13.8	88.8	

†All the coke produced in Alabama is made from Alabama coal.

1911							
3'400	2'028'202	22.8	3'121'822	213'132'121	221	2'020'342	22'05'140'121 212'320'
1912							
3'520	3'128'411	21.9	1'233'091	22'232'021	130	2'022'682	21'0'5'410'320 20'101'
1913							
3'200	1'102'332	22.9	1'001'411	23'028'422	135	2'021'110	20'9'5'010'334 22'422'
BEE-HIVE COKE							
BEE-HIVE COKE							
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Coke produced in beehive and by-product coke ovens in Alabama, 1915-1917.

1915

BEE-HIVE COKE					BY-PRODUCT COKE					TOTAL			
Active ovens.	Coal used (net tons)	Average yield (per cent.)	Coke produced (net tons)	Value of coke at ovens.	Active ovens.	Coal used (net tons)	Average yield (per cent.)	Coke produced (net tons)	Value of coke at ovens.	Coal used (net tons)	Coke produced (net tons)	Percentage to total U. S. production.	Value of coke at ovens.
2,506	1,708,228	58.6	1,001,477	\$3,086,656	732	2,987,710	69.3	2,070,334	\$5,458,899	4,695,938	3,071,811	7.4	\$8,545,555

1916

4,269	3,158,417	57.9	1,828,067	\$5,828,057	730	3,635,683	67.9	2,470,350	\$9,191,082	6,794,100	4,298,417	7.9	\$15,019,139
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1917

5,493	3,658,598	58.8	2,151,828	\$12,138,161	831	3,980,243	68.9	2,740,761	\$16,256,111	7,638,841	4,892,589	8.8	\$28,394,272
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Table showing increase of 1917 over 1916.

YEAR	BEEHIVE COKE				BY-PRODUCT COKE				TOTAL			
	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	Active ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	Coal used (net tons)	Coke produced (net tons)	Value of coke at ovens	
1916	4,269	3,158,417	1,828,067	\$5,828,057	730	3,635,683	2,470,350	\$9,191,082	6,794,100	4,298,417	\$15,019,139	
1917	5,493	3,658,598	2,151,828	12,138,161	831	3,980,243	2,740,761	16,256,111	7,638,841	4,892,589	28,394,272	
Increase	1,224	500,181	323,761	6,310,104	101	344,560	270,411	7,065,029	844,741	594,172	13,375,133	
Percentage	27.7	16.4	17.7	108.3	13.7	9.5	11.0	76.8	12.4	13.8	89.1	

VALUE.

Quantity (net tons) and value of coke produced in Alabama,
1912-1917.

	1912	1913	1914	1915	1916	1917	Increase	Percent- age	
								Total	
Quan.	2,975,489	3,323,664	3,084,149	3,071,811	4,298,417	4,892,589	594,172	13.8	
Value	\$8,098,412	\$9,627,170	\$8,408,443	\$8,545,555	\$15,019,139	\$28,394,272	13,375,133	88.8	88.9

Average value, per short ton and percentage of coke from coal, in
Alabama, 1911-1917.

	1911	1912	1913	1914	1915	1916	1917
Average value _____	\$2.75	\$2.72	\$2.90	\$2.73	\$2.78	\$3.49	\$5.80
Percentage yield _____	62.6	64.9	63.6	65.9	65.4	63.3	63.9

Quantity and value of coal used in the manufacture of coke in
Alabama in 1916 and 1917; and quantity and value of same
per ton of coke.

YEAR	Coal used (short tons)	Total value of coal	Value of coal per ton	Quantity of coal per ton of coke (short tons)	Value of coal to a ton of coke
1916 _____	6,794,100	\$11,000,238	\$1.62	1,581	\$2,561
1917 _____	7,638,841	18,776,218	2.46	1,561	3,840

COKE OVENS.

Coke ovens in Alabama, 1916 and 1917.

YEAR	Active		Idle		Total		Abandoned	
	Beehive	By-product	Beehive	By-product	Beehive	By-product	Beehive	By-product
1916.....	4,269	730	4,537	13	8,806	743	62	7
1917.....	5,493	831	3,320	16	8,813	847	1	

Coke ovens in Alabama at the end of 1911-1917

YEAR	Beehive	By-product
1911.....	9,781	340
1912.....	9,588	620
1913.....	9,584	700
1914.....	8,568	750
1915.....	8,568	750
1916.....	8,806	743
1917.....	8,813	847

Record of by-product ovens in Alabama, 1910-1917.

YEAR	Built	Building
December 31, 1910.....	280	340
December 31, 1911.....	340	280
December 31, 1912.....	620	100
December 31, 1913.....	700	20
December 31, 1914.....	750	0
December 31, 1915.....	750	0
December 31, 1916.....	743	97
December 31, 1917.....	847	0

By-product coke plants in Alabama in 1917.

Town	Name of company owning plant	Number of ovens	Type of oven	Year put in blast	Uses of coke	Uses of surplus gas	Benzol recovery plant
Ala. City	Gulf States Steel Co.	37	Koppers	1917	Blast furnace	Industrial fuel	Yes
Ensley	Tennessee Coal, Iron & R. R. Co.	240	Semet-Solvay	1898-1902	Blast furnace	Boiler fuel	Yes
Fairfield	Tennessee Coal, Iron & R. R. Co.	280	Koppers	1912	Blast furnace	Industrial fuel	Yes
Tuscaloosa	Central Iron & Coal Co.	60	Semet-Solvay	1906-1914	Furnace, foundry, and heating	Boiler fuel	Yes
Woodward	Woodward Iron Co.	170	Koppers	1911-1914	} Blast furnace	Industrial fuel	Yes
Woodward	Woodward Iron Co.	60	Wilputte	1917*		Industrial fuel	Yes

*1917—Additional benzol recovery plant operated by Thomas A. Edison.

CHARACTER OF THE COAL USED.

Ninety-four and two-tenths per cent of the coal used in the manufacture of coke in Alabama is washed before being charged into the ovens. In 1917, out of a total of 7,638,841 tons of coal made into coke, 7,193,146 tons were washed. Of the washed coal used 2,964,789 tons were slack, and 4,228,357 tons were mine run.

The unwashed mine run coal was 445,695 tons, while there was none of the slack unwashed.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last eight years, is shown in the following tables:

Character of coal used in the manufacture of coke in Alabama, 1890-1917, in short tons.

YEAR	Run of Mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890.....	1,480,669	0	206,106	123,189	1,809,964
1900.....	1,729,882	152,077	165,418	1,535,170	3,582,547
1910.....	771,931	1,308,085	0	3,192,306	5,272,322
1911.....	693,135	1,295,109	2,937	2,420,117	4,411,298
1912.....	747,305	896,421	18,793	2,922,979	4,585,498
1913.....	868,659	684,223	0	3,665,441	5,218,323
1914.....	703,241	2,069,638	0	1,905,317	4,678,196
1915.....	158,480	1,522,149	47,061	2,968,248	4,695,938
1916.....	238,849	2,352,907	0	4,202,344	6,794,100
1917.....	445,695	4,228,357	0	2,964,789	7,638,841

Character of coal used in the manufacture of coke in Alabama in 1914, 1915, 1916 and 1917, in short tons.

Year	Run of mine		Slack		Total			
	Unwashed	Washed	Unwashed	Washed	Unwashed	Percentage	Washed	Percentage
1914	703,241	2,069,638	0	1,905,317	703,241	15.0	3,974,955	85.0
1915	158,480	1,522,149	47,061	2,968,248	205,541	4.4	4,490,397	95.6
1916	238,849	2,352,907	0	4,202,344	238,849	3.5	6,555,251	96.5
1917	445,695	4,228,357	0	2,964,789	445,695	5.8	7,193,146	94.2

RANK OF THE STATES IN COKE PRODUCTION.

Coke was produced in 1917 in 22 states; in 5 only beehive coke was made. In the other states either the whole product came from by-product ovens, or both methods of coke-making were employed. In total output Pennsylvania heads the list, with Alabama, Ohio, Indiana, and West Virginia following in order. As regards the production of coke from by-product ovens the first five states rank Pennsylvania, Ohio, Indiana, Alabama, Illinois, while West Virginia ranks as No. 12.

The rank of the coke-producing states in respect of the total and of by-product output for the years 1913-1917 is shown in the following table:

Rank of the States in the production of coke, 1913-1917.

STATE	1913		1914		1915		1916		1917	
	Total		Total		Total		Total		Total	
	By-product	By-product	By-product	By-product	By-product	By-product	By-product	By-product	By-product	By-product
Pennsylvania	1	1	1	1	1	1	1	1	1	1
Alabama	2	3	2	3	2	3	2	3	2	4
Ohio	14	11	11	9	7	7	6	5	3	2
Indiana	3	2	3	2	3	2	3	2	4	3
West Virginia	4	12	5	14	5	13	4	15	5	12
Illinois	5	4	4	4	4	4	5	4	6	5
Virginia	6		6		10		7		7	
Colorado	7		7		9		8		8	
New York	8	5	12	8	8	6	11	7	9	6
Wisconsin	9	6	8	5	11	8	12	8	10	7
Michigan	11	8	9	6	6	5	10	6	11	8
Kentucky	16	14	13	11	12	12	9	12	12	10
Massachusetts	10	7	10	7	13	9	13	9	13	9
New Mexico	12		14		14		14		14	
Maryland	18	10	19	13	16	10	15	10	15	11
Minnesota	19	13	18	12	21	15	16	11	16	13
New Jersey	17	9	17	10	17	11	20	14	17	14
Tennessee	13		16		18	17	18	16	18	16
Utah	15		15		15		17		19	
Missouri					20	14	19	13	20	15
Washington	20		20	15	19	16	21	17	21	17
Georgia	21		21		22		22		22	

DISTRIBUTION.

Beehive coke shipped by originating railroads and waterways in Alabama in 1917.

RAILROAD	Shipments (net tons)	Production (net tons)	Percent. of production
Louisville & Nashville	615,906		
Southern	496,026		
Birmingham Southern: Ala. and Georgia	291,233		
Total	1,403,165	2,151,828	65.2

Coke produced in individual States in 1916, in net tons.

ALABAMA

DESTINATION.	Furnace	Foundry	Domestic fuel, and other kinds	Export
Alabama	4,048,471	157,323	393	
Arizona and Colorado		184	4,204	
Arkansas, Kansas and Oklahoma		762	200	
California		3,479		
Florida	155	1,274	72	
Georgia		13,411	581	
Illinois, Indiana and Virginia		236	121	
Kentucky		50		
Louisiana	231	41,173	586	
Mississippi		1,763	662	
Missouri		5,021	96	
North and South Carolina		175		
Oregon		126		
Tennessee		24,609	671	
Texas	1,444	16,256	3,827	
Total	4,050,301	265,842	11,413	14,984

CONSUMPTION.

Coke consumed in Alabama, exclusive of imports, in net tons.

YEAR	Furnace	Foundry	Dom. fuel and other kinds
1915	2,870,378	110,901	
1916	4,048,471	158,339	747

Coke consumed in Alabama in 1916, in net tons.

SOURCE	Furnace	Foundry	Dom. fuel and other kinds
Alabama	4,048,471	157,323	393
Georgia, Tennessee, Virginia and West Va.....		1,016	354
	4,048,471	158,339	747

Coke produced in Alabama in 1916 by uses, in net tons.

Furnace	Foundry	Domestic fuel and other uses	Exports	In (+) or out (—) of stock piles	Total production
4,050,301	265,842	11,413	14,984	—44,123	4,298,417

BY-PRODUCTS OBTAINED IN THE MANUFACTURE OF COKE.

1916.—The recovery of the valuable by-products obtainable from American coke ovens continued to make important gains in 1916. The quantities of by-products obtained increased approximately in ratio with the increase in the output of by-product coke, with the exception of the benzol products, which showed gains ranging in round figures from 400 to 1,800 per cent. The value of these benzol products amounted to \$30,000,000 in 1916, compared with \$7,340,000 in 1915 and less than \$1,000,000 in 1914, whereas the total value of all by-products obtained rose from \$30,000,000 in 1915 to \$62,000,000 in 1916.

Under the stimulus of war prices the number of plants equipped for benzol recovery increased from 30 in 1915 to 39 at the end of 1916. The benzol products obtained in 1916 amounted to 43,709,779 gallons. More than 16,500,000 gallons of the output was reported as crude light oil, with an average value of 30 cents a gallon. An increasingly large number of by-product plants operated their own refineries, and the output of pure benzol reported in 1916 from these sources increased nearly 750 per cent over the figures for 1915 and amounted to 21,079,500 gallons, with an average value of more than 62 cents a gallon. Similarly the reported production of toluol gained more than 500 per cent and amounted to 3,939,636 gallons in 1916, with an average value of slightly more than \$2.85 a gallon.

Approximately 185,500,000 gallons of tar was obtained from by-product coke ovens in 1916, the value of which was \$4,865,921.

The output in 1916 of ammonia, of which about 135,000 tons was reported as sulphate, 3,224,718 gallons as liquor, and 47,739,602 pounds as anhydrous ammonia, was equivalent to a total of 470,530,547 pounds of ammonium sulphate and had a value of \$14,152,243. Surplus gas, amounting to 110,062,000,000 cubic feet and valued at \$10,779,208 was sold or used, of which 20,552,000,000 feet was used as illuminating gas, 6,558,000,000 feet as domestic fuel, and 82,951,000,000 feet as fuel for raising steam for open-hearth furnaces in gas engines and for other industrial purposes. These by-products, which had a total value of \$61,931,595, were obtained by the carbonization of 26,524,502 net tons of coal, from which was also obtained 19,069,361 tons of coke, valued at \$75,373,070. The total value of the output of coke and by-products in 1916 was more than \$137,300,000, compared with \$78,300,000 in 1915.

1917.—Increased quantities of by-products were recovered from coke plants in 1917, the gain paralleling the continued expansion of the whole by-product coke industry. Benzol products remained the feature of greatest interest, and the number of plants equipped for their recovery rose from 39 in 1916 to 47 in 1917. Late in

1917 all toluol was commandeered by the War Department, and prices were set at a figure much below the prevailing market rates by a voluntary agreement between the Government and the toluol producers. In consequence, the aggregate value of these products declined from \$30,000,000 in 1916 to \$28,500,000 in 1917, although production increased nearly 25 per cent, the total volume of benzol products amounting to 54,387,266 gallons in 1917.

Additional plants were equipped for refining their light oil fractions, with the result that the quantity of crude light oil reported for 1917 was only about 7,500,000 gallons, compared with 16,500,000 gallons in 1916, while pure benzol reported from these sources increased from 21,000,000 gallons in 1916 to nearly 37,000,000 gallons in 1917, with an average value per gallon for the latter of 45 cents. Nearly twice as much toluol (7,395,174 gallons) was produced at by-product plans in 1917 as in 1916. Because of the price agreement with the Government, the average value per gallon of toluol was \$1.37 in 1917, compared with \$2.85 in 1916.

Tar obtained from by-product ovens amounted to 221,999,264 gallons in 1917, valued at \$5,566,302.

The output of ammonia in 1917, equivalent to 560,792,322 pounds of ammonium sulphate, had a value of \$17,903,864.

Surplus gas, amounting to 131,027,000,000 cubic feet, and valued at \$11,360,335, was sold or used in 1917, of which 21,289,000,000 feet was used for illuminating purposes, 7,271,000,000 feet was reported as domestic fuel, and 102,466,000,000 feet served as industrial fuel for open-hearth furnaces, in gas engines, and for other purposes.

By-products obtained in 1917 had a total value of \$67,670,679 and their production required the carbonization of 31,505,759 net tons of coal, from which was also obtained 22,439,280 net tons of coke valued at \$138,643,153. The total value of the output of all by-product ovens in 1917 was more than \$206,300,000, compared with \$137,300,000 in 1916 and \$78,300,000 in 1915.

The yield of coke per ton of coal in different plants ranged from 1,106 to 1,682 pounds. Several operators reported the recovery of more than 10 gallons of tar from 2,000 pounds of coal; one reported 13.5 gallons and one as little as 4.8 gallons. Twenty-one operators reported their ammonia entirely in the form of sulphate, and the average recovery in these operations was 19.85 pounds of sulphate per ton of coal. Twenty-three operators reported their ammonia as pounds of NH_3 , with an average of 4.96 pounds of NH_3 recovered from each 2,000 pounds of coal. The other operators reported their ammonia either wholly or in part as liquor or as sulphate and NH_3 . Individual operations showed average recovery ranging from 3.2 to 6.2 pounds of NH_3 and from 12.1 to 26.3 pounds of ammonium sulphate per ton of coal.

Some plants are not equipped for fractionating the oils of the benzol group, but ship their crude products to refineries or chemical works for further treatment, and for that reason part of these products were reported and are shown here as crude and secondary oils.

GRAPHITE.

By HENRY G. FERGUSON.

INTRODUCTION.

THE peculiar physical properties of graphite—infusibility, chemical inertness, high conductivity, extreme softness, and low specific gravity—fit it for many uses, such as the manufacture of crucibles and other refractory products, lubricants, lead pencils, paint, foundry facings, as a preparation to loosen boiler scale, as polish for gunpowder, and for various applications in electrical works.

Natural graphite may be either crystalline or amorphous. The term crystalline or flake graphite is commonly understood to mean graphite in crystals large enough to be visible to the naked eye; much of the so-

called amorphous graphite shows a crystalline structure under the microscope. Crystalline graphite occurs either in veins, as in the Ceylon deposits, or as flakes disseminated through the country rock, as in most of the crystalline graphite deposits of the United States. Most deposits of amorphous graphite are the result of the alteration of coal beds by the intrusion of igneous rocks. Amorphous graphite is also made artificially by means of the electric furnace.

USES OF GRAPHITE.

By far the most important use of graphite is in the manufacture of crucibles, and for this reason graphite is a mineral resource of vital importance in time of war, and American producers of flake graphite have greatly increased their output. The makers of crucibles have also greatly increased their production during the last two years. Graphite for making crucibles must be of great purity. Its content of graphitic carbon should exceed 85 per cent and should preferably be as high as 90 per cent, and it must be practically free from mica, pyrite, and iron oxide. A small amount of quartz is not injurious. Graphite for making crucibles should also be coarse enough for the interlocking fragments to be easily bound together by the clay with which it is mixed. It should preferably contain a large proportion of flakes about 1 millimeter in diameter and should all remain on a 100-mesh sieve.

Most makers of crucibles prefer to use Ceylon graphite mixed with 10 to 25 per cent American flake in part because the more nearly cubical fragments of Ceylon graphite have a much smaller surface area in proportion to their volume than the thin flakes of the domestic graphite and hence require proportionately less clay as a binder. Ceylon graphite is also more nearly free from undesirable impurities such as mica and pyrite. It is possible, however, to use domestic flake graphite alone with good success in crucible manufacture. In recent commercial tests of crucibles made with Alabama flake graphite and domestic clay three No. 80 crucibles, tested in copper

melting, gave 21 heats each, and a fourth 42 heats. There is, however, no immediate prospect of a sufficiently increased domestic production to supply the needs of crucible manufacturers, and graphite must still be imported from Ceylon or Madagascar, but it is believed that the percentage of domestic material used could be increased. The only American graphite resembling the Ceylon material is produced in small amount in Montana.

The difficulties encountered since 1914 in finding satisfactory supplies of clay have now been largely overcome, and the crucibles made with domestic clays are of much better grade than formerly. A part of the great demand for crucibles has been due to the fact that crucibles made with domestic clays did not stand as many heats as those made with the Bavarian clay and consequently a larger number were required to accomplish the same work. According to McNaughton,* the results attained in the early attempts to use domestic clays were very unsatisfactory. In certain tests only 4 or 5 heats were secured with crucibles of average size, as against 25 to 30 heats before the war. At present from 15 to 25 heats is the range of average service. The cost of the domestic clay, however, is more than double that of the German clay used prior to the war.

Graphite for other uses does not require the same grade of material as for crucibles, and for most purposes amorphous graphite can be used with as good effect as the crystalline variety. Graphite for foundry facings, commonly known as "silver lead," is of varying degrees of purity, according to the work required. Ceylon dust was formerly used to a considerable extent for this work, but the present high prices, due to the high freight rates, have greatly decreased its use. Next to crucibles, foundry facings probably absorb more graphite than any other single use.

Lubricating graphite must be of a high degree of purity and absolutely free from gritty substances, such as quartz. As size of grain is not essential, either amorphous or crystalline graphite may be used.

*McNaughton, M., The crucible situation: *Metal Industry*, vol. 15, pp. 431-432, 1917.

For pencils either amorphous graphite alone or a blend of amorphous and fine-grained crystalline graphite is employed. The graphite is mixed with clay in varying proportions, according to the hardness desired. In order that the product shall be uniform, very pure graphite is required.

For other uses, such as fillers for dry batteries, facings for molds, polish for explosives, paints, boiler mixture, and many similar requirements, either crystalline or amorphous graphite may be used, and the degree of purity essential varies according to the nature of the use.

IMPORTS.

The following table shows the imports of graphite into this country since 1913. As the war has disarranged the usual trade routes and as the statistics of the Bureau of Foreign and Domestic Commerce necessarily show only the country from which shipments were made, it is necessary to draw some inferences as to the country of origin. Graphite entered in the import statistics as coming from France is probably all of Madagascar origin, and all graphite imported from Great Britain has been assigned to Ceylon. Similarly shipments from Japanese ports are assumed to represent Chosen graphite as the Japanese production is of minor importance. The imports from Canada in 1914 and 1915 were in excess of the Canadian production for these years, so it is probable that these imports include a certain amount of Ceylon material.

Graphite imported into the United States, 1913-1917.*

COUNTRY EXPORTING	Probable country of origin	QUANTITY (SHORT TONS)						VALUE			
		1913	1914	1915	1916	1917		1914	1915	1916	1917
Other British East Indies	Ceylon	16,996	8,374	12,275	24,411	24,304	\$1,674,764	\$920,147	\$1,564,917	\$5,846,515	\$7,075,143
England	Ceylon		381	2,216	561	6		42,446	261,321	166,847	1,566
British India	Ceylon		127		1,260	265		9,815		343,170	102,499
Total, Ceylon		16,996	8,882	14,491	26,232	24,575	1,674,764	972,408	1,826,238	6,356,532	7,179,208
Netherlands	(?)			36					2,811		
Dutch East Indies	(?)				169					21,484	
Madagascar	Madagascar		155	36				18,426	2,831		
France	Madagascar		194	1,432	1,631	4,393		20,278	181,236	241,863	1,057,081
Total, Madagascar			349	1,468	1,631	4,393		38,704	184,067	241,863	1,057,081
Canada	Canada	1,662	1,806	2,995	4,127	3,476	98,665	92,536	116,407	314,177	349,034
Brazil	Brazil				1	18				75	4,380
Mexico	Mexico	4,435	4,259	1,680	5,331	7,570	198,000	190,075	75,000	238,000	285,568
Chosen	Chosen				337	137				10,534	5,483
Japan	Chosen	4,170	6,327	2,373	5,038	2,314	58,199	96,433	35,292	93,085	77,652
Japanese China	Chosen					11					423
Total, Chosen		4,170	6,327	2,373	5,375	2,462	58,199	96,433	35,292	103,619	83,558
Italy	Italy	236	254	27	151	115	4,061	3,203	994	4,133	3,092
Austria	Bohemia	660	78				9,957	1,258			
Germany	Bavaria	90					4,034				
Other countries		630	47	5			62,111	3,644	354		67
Grand total		28,879	22,002	23,077	43,017	42,609	2,109,791	1,398,261	2,241,163	7,279,883	8,961,988

*Compiled from reports of the Department of Commerce.

DOMESTIC PRODUCTION.

CRYSTALLINE GRAPHITE.

The increase in metal manufacture incident to the progress of the war has brought a greatly increased demand for crucible graphite, and the amount of graphite suitable for crucible use, both domestic and imported, consumed during the year was approximately 30,000 short tons, as against 13,500 short tons in 1913. The domestic production has responded to the greater demand and during the last three years has shown a steady increase.

The actual mine production during 1917 has shown a notable gain. The total production, including stocks on hand at the mines, was approximately 14,000,000 pounds as against about 10,900,000 pounds in 1916. The figures for sales, however, which are used as the basis of the following tables, show a slight decrease. This is due principally to the facts that owing to the freight congestion the Alabama producers have had great difficulty in shipping their product and that many new companies have been unable to begin production owing to delay in procuring the necessary equipment. During the last three months of 1917 shipments of crystalline graphite from the Alabama field were only about 25 per cent of the capacity of the mills. The extremely severe winter also curtailed production, both in Alabama and in New York. In Pennsylvania the sharp decrease compared with 1916 is due to the remodeling of several of the larger plants. Many of the mills had large stocks on hand at the end of the year, but as the Survey's figures of production are based on sales, the amount of these stocks is not included in the total for the year.

Estimates furnished by the producers of crystalline graphite show that out of the total sales of 10,584,080 pounds, 6,816,913 pounds, valued at \$982,336, or about 64 per cent by weight and 90 per cent by value of the total, was flake graphite containing from 80 to 90 per cent graphitic carbon, in large part suitable for crucible use. The remainder, 3,767,167 pounds, valued at \$112,062, was dust or low-grade flake probably averaging under 50 per

cent graphitic carbon. The proportion of flake produced is higher than in previous years, owing in part to improved milling methods, whereby a larger proportion of the graphite was saved as flake, and in part to the fact that because of the freight embargo during the later part of the year such shipments as the Alabama producers were able to make consisted mainly of the better-grade material.

As usual, the greater part of the domestic crystalline graphite was produced in Alabama, New York, and Pennsylvania. The production of these states was all of the variety known in the trade as flake graphite, which occurs as small flakes forming 3 to 10 per cent, by weight, of crystalline schists. In addition, crystalline graphite, resembling in a general way the Ceylon graphite, was produced in Montana, and a small quantity of flake graphite was mined in California and Texas. The quantity of crystalline graphite in 1917 was slightly less than the sales for the preceding year, but the value showed an increase of 20 per cent over 1916. The number of producers of crystalline graphite was 14 in Alabama, 1 in Alaska, 1 in California, 1 in Montana, 4 in New York, 5 in Pennsylvania, and 1 in Texas.

Crystalline graphite sold in the United States, 1916 and 1917.

	1916				1917	
	Quantity (pounds)	Value	No. 1 and No. 2 flake (pounds)	Other grades (pounds)	Total	
					Quantity (pounds)	Value
Alabama _____	5,226,940	\$492,407	4,295,233	1,927,862	6,223,095	\$719,575
New York _____	*	*	1,656,897	1,284,143	2,941,040	261,548
Pennsylvania _____	1,095,716	103,377	549,783	255,162	804,945	77,475
Other states† _____	4,609,333	318,964	315,000	300,000	615,000	35,800
	10,931,989	914,748	6,816,913	3,767,167	10,584,080	1,094,398

*Included in "Other States."

†1916: California, Montana, New York, and Texas; 1917: Alaska, California, Montana, and Texas.

AMORPHOUS GRAPHITE.

The production of amorphous graphite during 1917 was 8,301 tons, valued at \$73,481, as compared with 2,622 tons, valued at \$20,723 in 1916. As amorphous graphite is not suitable for use in crucible manufacture, war conditions have not increased the demand for it to so marked a degree as for crystalline graphite. Moreover, the production of flake graphite for crucible use yields a large amount of dust as a by-product, and this dust is available for practically all uses to which amorphous graphite can be put.

The better grades of amorphous graphite are imported from Mexico and Chosen, and the imports, like those of crystalline graphite, greatly exceed the domestic production. Artificial amorphous graphite is also a competitor of the natural product.

Amorphous graphite was produced by 6 mines in 1917, as against 5 in 1916. The producing states were Colorado, Michigan, Nevada, and Rhode Island. On account of the small number of producers, figures showing the production by states can not be published without disclosing individual returns.

ARTIFICIAL GRAPHITE.

Graphite is manufactured chiefly by the International Acheson Graphite Co., which utilizes electric power generated at Niagara Falls. The output has increased greatly in recent years and now forms an important element in the country's graphite supply. The bulk graphite is made either from anthracite or from petroleum coke and is utilized mainly in lubricants and paints and for foundry facings, boiler-scale preventives, and battery fillers.

Besides the graphite products that enter into competition with natural graphite, there are a large number for which artificial graphite is particularly adapted. Chief among these is graphite electrodes, the demand for which has greatly increased during the last three years on account of the remarkable growth in certain electrochemical industries.

MARKETS AND PRICES.

Domestic flake graphite brought slightly higher prices in 1917 than in 1916. The prices received at the mines for the best grades ranged from 12 to 18 cents a pound for No. 1 flake, according to its grade; from 6 to 10 cents a pound for Nos. 2 and 3; and from half a cent to 5 cents a pound for dust. Flake graphite containing 90 per cent or more of graphitic carbon sold for considerably higher prices than the usual product containing 85 per cent carbon or less. Prices reported by purchasers were, in general, from 12 to 17 cents a pound for No. 1 flake and occasionally prices as high as 20 cents a pound for special lots, $9\frac{1}{2}$ to 12 cents for No. 2, and 1 cent to 9 cents for lower grades. Ceylon graphite was hard to obtain during the summer, and domestic flake was consequently in great demand, but in September large quantities of Ceylon graphite became available and the manufacturers no longer required the domestic product. This new supply, coupled with the difficulty of rail shipments, due to the freight embargoes, seriously affected the domestic industry.

The prices paid at the mines for the highest-grade domestic graphite have been as follows: 1911 and 1912, 6 to 7 cents a pound; 1913, 6 to 8 cents; 1914, $6\frac{1}{2}$ to 8 cents; 1915, 7 to 10 cents; 1916, 10 to 16 cents; 1917, 12 to 18 cents.

Ceylon graphite of the better grades is more largely used by crucible makers than domestic flake graphite and even in normal times commands a higher price. During the last three years the tremendous increase in crucible manufacture has caused a demand for the Ceylon product greatly in excess of the available supply and the price has constantly increased. The sharp increase of price for all grades of Ceylon graphite in 1916 over that for previous years was due in part to the fact that a much larger proportion of the highest-grade product was imported. During 1917 the prices of Ceylon graphite in the eastern market were approximately as follows: Lump, 27 to 30 cents a pound; chip, 19 to 24 cents; dust, 7 to 14 cents, according to grade. These prices show only a slight increase over those for 1916.

Madagascar graphite is a flake graphite similar to the crystalline graphite produced in this country, but the flakes are larger and thicker. The prices during 1917 ranged from 11 to 14 cents a pound, or slightly lower than those for domestic graphite. The Mining Journal (London) since June 9, 1917, has given weekly quotations for Madagascar graphite based on 80 and 85 per cent carbon with an allowance of 15 francs per metric ton per unit of variation. These quotations showed a range in prices (f. o. b. Tamatave) of 900 to 950 francs per metric ton for 85 per cent material. During the later part of the year the price quoted was 1,250 francs f. o. b. Marseille for 80 per cent material, or about 10 cents a pound at prevailing exchange rates, and 900 francs f. o. b. Tamatave for 85 per cent, in each case with an allowance of 15 francs per unit of carbon variation. The average value of material imported into this country, as shown by the import figures of the Bureau of Foreign and Domestic Commerce, is 12.3 cents a pound.

The following table shows the average prices of Ceylon and Madagascar graphite imported into this country, as compiled from the records of the Bureau of Foreign and Domestic Commerce, and the average prices of all grades of domestic crystalline graphite, including both dust and flake, as reported by the producers. The sharp increase in the price of Ceylon graphite in 1916 appears to be due to the diminished import of lower-grade material as well as to enhanced prices for the better grades:

Average price of crystalline graphite, in cents a pound, 1912-1917.

	Ceylon	Madagascar	Domestic		Ceylon	Madagascar	Domestic
1912	4.1		4.2	1915	6.3	6.3	5.9
1913	4.9		5.0	1916	12.0	7.4	8.4
1914	5.5	5.5	5.5	1917	14.6	12.3	10.3

Domestic amorphous graphite brought widely varying prices, according to the grade of the material mined.

Although the demand was generally good, the prices do not appear to have increased greatly during the year.

Chosen amorphous graphite, which before the war sold at about \$22 a ton, during 1917 brought from \$45 to \$60 a ton. The amount available was not as large as in former years, and the Chosen material appears to be in large measure supplanted by Mexican, domestic, and artificial amorphous graphite.

In order to assist producers in marketing their product, the Geological Survey has prepared a list of firms known to be purchasers of domestic graphite. This list will be mailed free on request to the Director, United States Geological Survey.

ALABAMA—GENERAL FEATURES.

The Alabama graphite mines in 1917 furnished approximately 59 per cent of the quantity and 66 per cent of the value of the domestic crystalline graphite sold—an increase of 19 per cent in quantity and 46 per cent in value over 1916, and 3 times the quantity and 8 times the value of Alabama's output in 1913. Sales were reported by 14 companies in 1917, and 25 others have begun operations since the beginning of 1918 or expect to begin in the near future. Work has been most active in the Ashland district in Clay County. The producing companies number 11 in Clay County, 2 in Coosa County, and 1 in Chilton County. In spite of the great increase in the number of companies only a comparatively small portion of the graphite-bearing area is yet under development, and for the most part the operations are confined to localities near the power lines of the Alabama Power Co.

The embargo on freight shipments during the later part of 1917 seriously affected the Alabama production, and many of the mines were unable to make shipments to the northern markets. During the last quarter of the year the production was only about 25 per cent of the maximum capacity of the mills. The principal reason for the shortage was the freight embargo, but the shortage of labor and the severe winter were also important factors.

The Alabama flake graphite from different mines varies greatly in purity, and lack of standardization hinders the full development of the deposits. A few companies produce a No. 1 flake containing 90 per cent carbon, others maintain an 85 per cent standard, and some market flake averaging only about 80 per cent.

The following analyses, furnished through the courtesy of one company, shows the content of the average grade of the Alabama product. No 1 represents samples from 5 tons and No. 2 from 3 tons of flake.

Analyses of Alabama flake graphite.

	1	2
Volatile matter	2.00	1.08
Carbon (graphitic)	84.00	84.72
Ash	14.00	14.20
	100.00	100.00
Iron	.97	
Sulphur	.08	

Ash analysis of sample 2.

	Ash	Percentage for entire product
Fe ₂ O ₃	8.32	1.18
Al ₂ O ₃	22.94	3.26
SiO ₂	64.27	9.13
CaO	Trace	Trace
MgO	1.43	.20
S	.32	.05
Alkalies	2.78	.39
	100.06	14.21

The ash analysis indicates that the principal foreign impurity in the finished product is silica, with a little clayey matter, very little mica, and almost no pyrite.

The graphite occurs in a graphitic schist which forms lenses in a series of metamorphic rocks traversing parts

of Clay, Coosa, and Chilton counties. Quartz is the principal constituent of the graphite-bearing schist, with subordinate amounts of pyrite, mica (biotite), and apatite. These bands of schist rarely exceed 100 feet in thickness and appear to be fairly continuous, though prospecting has not yet proceeded sufficiently to establish their continuity over long distances. The average graphite content of the ore in terms of graphitic carbon is 3 or 4 per cent, though in some places analyses show a carbon content of 5 or 6 per cent. In nearly every deposit the graphite schist is intruded by small stringers of pegmatitic granite. These contain only a little graphite, but appear to have caused a more intense recrystallization of the original carbon in the intruded rock, which has resulted in a coarsening of the flake in the immediate vicinity and possibly in an actual enrichment in the graphite content. The wall rocks are in most places schists that are similar in type to the graphite-bearing schist but contain less graphite and more mica. At a few localities, however, one wall consists of hornblende schist, probably an altered basic intrusive. No graphite is found where the hornblende schist is intruded by granite—an evidence that the carbon from which the graphite is derived is not a product of the granite intrusion. The graphite schists commonly crop out along ridges, and, as a rule, the overburden is very light. The pyrite of the deposits is in most places completely oxidized to the depth of 50 to 60 feet. Besides removing this very objectionable constituent of the ore, weathering has softened the rock and lessened the coherence between the graphite and the other minerals, which facilitates both mining and concentration. The unoxidized schist is avoided as far as possible in mining operations, as it is hard to crush, and the pyrite can be completely eliminated from it only with difficulty. It would, however, be perfectly feasible to treat this "blue rock" should necessity arise.

The following recent articles are of interest in regard to the graphite deposits of Alabama:

Prouty, W. F., Flake graphite in Alabama; its location, its history, and its value to the State: Birmingham Age-Herald, January 28, 1917.

——— Extent and development of flake graphite resources of Alabama: *Manufacturers' Rec.*, April 19, 1917, pp. 66-67.

Pratt, J. H., Alabama graphite deposits: *Manufacturers' Rec.*, March 22, 1917, p. 58.

Herr, Irving, Clay County graphite district of Alabama: *Eng. and Min. Jour.*, vol. 103, pp. 693-697, April 21, 1917.

MINING AND CONCENTRATION.

Mining is done in open cuts, and in common practice a 30-foot face is broken down with a single charge of dynamite and the material loaded into cars. The large blocks are broken by hand or by small charges of powder. In loading a certain proportion of low-grade material is discarded. The deposits with steep dips are, of course, at an advantage over others in the costs of mining.

Milling methods are much the same in most of the mills and may be described briefly. Large bins have been installed in most of the newer mills to allow steady runs even in wet weather, as it is of great advantage to have the ore as dry as possible. The ore passes to a jaw crusher, where it is broken to about 1-inch size and next to a rotary cylindrical drier. In some mills rolls are used before drying. The dry ore is next crushed in rolls and screened, the oversize going back to the rolls and the fines passing to the water flotation concentrator. In some mills the crushed ore first passes through an air separator in which a suction fan removes the graphite and dust and leaves the coarser sand behind. This process is open to the objection that a certain quantity of coarse flake is left behind with the sands and some fine graphitic dust is inevitably lost. Where a middling product is made it is returned to the rolls. In some of the newer mills the graphitic sands pass from the drier into cooling bins, where they remain 24 hours, the bins being drawn on alternate days. The reason for this is that water flotation has been found to act more effectively on cool material.

The principal concentration process is water flotation. The flotation separator is a rectangular trough 5 to 9 feet long, 6 to 10 inches wide, and 12 to 18 inches deep. This trough is filled with water, which is supplied in a thin curtain from the top along the entire length of one side

and overflows into a launder on the other side. The amount of water is regulated so that the flow across the trough shall be as smooth and free from ripples as possible. The graphitic sand is fed in a thin stream onto the moving water surface. In a few mills the sand is fed over a revolving shaft which distributes the feed more evenly. Most of the sand sinks, and the graphite flakes, together with a little mica and fine grit, float off on the moving water. A recent modification of the flotation separator is circular in form and about 6 feet in diameter, and in it the sand is fed at the apex of a stationary or revolving cone.

The launders carry the concentrates to shaking screens, on which they are freed from surplus water. Fine sprays falling on these screens wash out a part of the fine grit. In one mill a hexagonal reel is used instead of the shaking screen. The concentrates are next dried on a concrete drying floor heated by steam or in double-chambered rotary cylindrical driers. In some mills the concentrates then pass through another air separator. This removes whatever coarse grit has been floated with the graphite.

The finishing process consists of grinding in burrstone mills and screening in bolting reels or inclined shaking screens of the kind used in flour mills. The purpose of the burr mill is to break the grains of quartz so that they will pass through the finest screen with the dust while the No. 1 and No. 2 flake remains as oversize from the different screens. In a few mills electrostatic separation has been tried in place of burr mills for the final finishing, but in the Clay County mills it has not proved satisfactory.

Three mills use processes different from that outlined above. The new mill of the Alabama Graphite Co. uses a wet process for the preliminary concentration. The material is crushed in jaw crushers and is then fed with water into the muller and from that to a log washer, in which the sands are screened toward the discharge at the upper end while the graphite flakes float off at the lower end. The dewatering and finishing process is the same as that outlined above. The Ceylon Co. uses an oil-flota-

tion process and the Flaketown Graphite Co. uses a dry process throughout.

The usual Alabama system as outlined above is open to the following objections:

1. The recovery is low; in most mills the total of the finished product amounts to about 2 per cent of the ore handled. As none of the final product is pure graphite, this probably means a total saving of not over 60 per cent of original graphite content.

2. The quantity of dust is too great in proportion to the quantity of No. 1 flake produced. The proportion of different products varies from 40 to 50 per cent of No. 1 flake, 25 to 15 per cent of No. 2 flake, and 40 to 35 per cent of dust. Grinding dry in the muller or Chile mill and the final grinding in the burr mills probably breaks the flake badly.

3. Under the present system the ore must be dried before the graphite can be separated by water flotation and the concentrates must be dried again before finishing. A wet concentration process would eliminate the preliminary drying.

4. There is no uniform standard for No. 1 flake. A few producers guarantee a 90 per cent carbon content but the majority produce No. 1 flake carrying about 85 per cent.

5. The dust-filled mills can not fail to be injurious to the health of the workers.

The organization of the Graphite Association of Alabama (A. B. Conklin, secretary, Ashland, Ala.) has been of great assistance to the industry, as it enables the graphite producers of the State to take united action in matters affecting the mining industry, such as the railroad embargo. The association is preparing to obtain a better standardization of the Alabama flake.

The following Alabama companies either reported sales during 1917 or expected to begin operations during the early part of 1918:

Graphite producers in Alabama.

Chilton County:	
Company:	Location of plant:
Flaketown Graphite Co., Mountain Creek	Mountain Creek

Clay County:	
Acme Graphite Co., Ashland	Ashland
Alabama Graphite Co., Ashland	Ashland
C. B. Allen Graphite Co., Ashland	Ashland
American Graphite Co., Gadsden	Ashland
Ashland Graphite Co., Ashland	Ashland
Atlas Graphite Co., Ashland	Ashland
Axton Noe Graphite Co., Ashland	Ashland
Clay County Graphite Co. (Inc.), Ashland	Ashland
Crystalline Flake Graphite Co., Birmingham	Ashland
Empire Graphite Co., Ashland	Ashland
Griesemer Graphite Co., Ashland	Ashland
Hood Graves Graphite Co., Alexander City	Ashland
Jefferson Graphite Co., Birmingham	Ashland
May Bros. Graphite Co., Ashland	Ashland
National Flake Graphite Co., Ashland	Ashland
Republic Graphite Co., Ashland	Ashland
Southern Graphite Co., Ashland	Ashland
Superior Flake Graphite Co., Ashland	Ashland
Crucible Flake Graphite Co., 50 Broad street, New York, N. Y.	Ashland
Carbon Mountain Graphite Co., Lineville	Graphite
Liberty Graphite Co., Birmingham	Lineville
Jennings Graphite Co., Lineville	Lineville
Morris Graphite Co., Lineville	Lineville
King Graphite Co., Lineville	Lineville
Lineville Graphite Co., Lineville	Lineville
Peerless Flake Graphite Co., Lineville	Lineville
Eagle Graphite Co., Ashland	Quenelda
Norway Graphite Milling Co., Clairmont Springs	Quenelda
Quenelda Graphite Co., Quenelda	Quenelda

Coosa County:	
Ceylon Co., Birmingham	Hollins
Duro Graphite Co., Sylacauga	Sylacauga
Graphite Co. of America, Goodwater	Good Water
Good Water Graphite Co., Good Water	Good Water
Parkdale Graphite Products Co., Talladega	Parkdale

FUTURE OF THE GRAPHITE INDUSTRY.

DOMESTIC.

Even at the present war prices the miners of this country who are working deposits of disseminated flake graphite must depend on their No. 1 and No. 2 flake for their profit. The dust and lower-grade flake produced are

merely by-products and are salable only at a very low price. The object of the operators is consequently to produce as large a proportion of flake as possible. The usual process of finishing involves grinding in burr mills in order to break the small particles of quartz and allow them to be separated out by screening. This process necessarily breaks the flake and increases the amount of dust. Developments in graphite milling practice during 1917 give promise of a largely increased production of flake of better grade. Among the new methods is oil flotation, particularly in the Alabama field, where several companies are using it with marked success. If flake graphite holds its present prices, profits can be made by a mill of almost any type, but at the prices that prevailed in time of peace only the most efficiently managed mills can hope to survive. Madagascar's output is increasing rapidly, and after the war domestic producers will have to meet competition from this island as well as from Ceylon. If Madagascar graphite can in normal times be put on the London market at a cost of approximately 4 cents a pound,* the price at New York would not be much higher, and it can readily be seen how formidable a competition will have to be met by the domestic producers when the shipping situation becomes normal again and how essential it is that the methods of mining and milling should be brought to as high a degree of efficiency as possible. The Ceylon graphite is considered by American manufacturers to be better suited to the manufacture of crucibles and will probably continue to command a higher price than the domestic. The costs of mining in Ceylon have advanced considerably in recent years, however, since deep mining has become necessary, and it is probable that unlike Madagascar, which is a new field, Ceylon will not increase her production greatly. Moreover, it is probable that the greater use of the electric furnace in metallurgic operations will somewhat retard the demand for graphite crucibles. The following table shows the notable development in electric-furnace steel during the last few years, while the production of crucible steel has remained about stationary.

*Shelley, J. W., Graphite in Madagascar: *Min. Mag.*, vol. 14, p. 327, 1916.

Steel ingots and castings, produced in the United States, 1908-1916, by processes, in gross tons.*

	Crucible	Electric		Crucible	Electric
1908.....	63,631		1913.....	121,226	30,180
1909.....	107,355	13,762	1914.....	89,869	24,009
1910.....	122,303	52,141	1915.....	113,782	69,412
1911.....	97,653	29,105	1916.....	129,692	168,918
1912.....	121,517	18,309			

*Am. Iron and Steel Inst. Ann. Rept. for 1916, p. 24, New York, 1917.

Under conditions such as prevailed in the summer of 1917 nearly any grade of flake graphite is salable, and there are no definite standards governing specifications. Consequently, other things being equal, the buyer will prefer the imported graphite, for which there are fairly well recognized standards. It would seem advisable for the domestic producers, now that their product is in good demand, either to adopt standards for different grades of flakes, in order that when imported graphite comes on the market more freely they may be better able to meet the competition, or so to regulate their milling methods that they may be able to prepare special grades based on the purchaser's specifications. It is probably impossible to standardize grades for the whole country, owing to the different methods of treatment necessary for different types of ore, but where conditions are essentially the same over a large area, as in the Alabama field, co-operation among the producers might result in the establishment of two or three standard grades, based on the percentage of graphitic carbon and size of flake, with a guaranteed minimum of silica and iron. This would give the producers a far stronger position in the market and make the crucible manufacturers more ready to use domestic flake.

Graphite for other uses, such as for lubricants, pencils, foundry facings, and paints, will probably continue to be in good demand, but unless the deposits are large and cheaply mined, the prices of the grades required for these uses do not make them profitable to the producer. Here again the expected competition after the war of the

graphite dust from Madagascar and Ceylon and amorphous graphite from Mexico and Chosen, as well as artificial amorphous graphite, will be difficult to meet. Better milling methods, resulting in a higher graphite content of the dust produced, will aid the situation greatly. For instance, dust as ordinarily produced at flake graphite mines carried about 40 per cent carbon and is sold at less than 1 cent a pound, but this same dust when refined to a degree of purity suitable for use as a filler for dry batteries commands many times this figure.

Perhaps it may be found feasible to manufacture many graphite products in the vicinity of the mines. In this connection an article by Bartley is worthy of attention.

The large number of new companies beginning operations at the present time naturally makes it of importance to consider the probable effect of the future increased production upon the market. If all the mills in the Alabama field are able to operate at anything like their expected capacity, the result will be an annual production of flake graphite of approximately 30,000,000 pounds, about 15 times the production of Alabama in 1913, and nearly equal to the entire importation from Ceylon for that year. As long as the war continues a largely increased production can probably be absorbed by crucible makers and other users of crystalline graphite, but if the graphite from Ceylon and Madagascar continues to enter the market freely, the price of domestic graphite will necessarily be reduced with the increase in production. On the other hand, mining conditions in Alabama are very favorable, the mining costs are low, and new developments in concentration and finishing will probably result in a larger percentage of good flake in the finished product and a higher saving of graphite of all grades. Costs of mining and milling at an efficiently managed plant should not exceed \$50 a ton of concentrates produced, or about $2\frac{1}{2}$ cents a pound for the finished product, and even with prices as low as 5 cents a pound for No. 1 flake, 3 cents for No. 2, and $1\frac{1}{2}$ cents for dust, there should still be a possibility of profit. A recent article by Prouty* contains an interesting discus-

*Prouty, W. F., Extent and development of flake graphite resources of Alabama; *Manufacturers' Rec.*, Apr. 19, 1917, pp. 66-67.

sion of costs of production of graphite in Alabama. It is of course idle to speculate on the possible duration of present conditions, and the situation may be summed up by saying that as long as the present demand for crucibles in the manufacture of munitions continues, the plants in operation should all be able to make profits, and even with the expected drop in prices after the war the most favorably situated and efficiently managed plants should continue to be profitable.

With a return of peace, however, operators will face an unfavorable condition caused by a decreased market and large increase in production.

IRON ORE.

ERNEST F. BURCHARD.

EUGENE A. SMITH.

ESSENTIAL FEATURES OF AN IRON-ORE DEPOSIT.

THE war in Europe has greatly stimulated prospecting for minerals and ores in the United States, and as a result of this prospecting many specimens are sent to the United States Geological Survey for identification. The majority of specimens are readily identified at sight; some require a brief visual examination; others require more elaborate physical or chemical tests. The Survey is not permitted to make chemical analyses or assays of minerals or ores for private persons or corporations, but it is compatible with the duties of the Survey to inspect a specimen and to state, if possible, what it is; to give an offhand opinion as to whether or not the material constitutes an ore; and to recommend or discourage further expense in prospecting it or in having analyses or assays made.

Iron minerals are among the most common and are abundantly distributed, and naturally many specimens are received by the Geological Survey. It is therefore

believed that a few notes on these minerals and on the requirements of a deposit in order to render it of commercial importance may be of interest to those making inquiries on the subject. The classes of iron minerals that constitute a source of iron ore are oxides and carbonates. There are three general varieties of oxides, viz., hematite, brown ore, and magnetite. Brief descriptions of each follow:

SOURCE OF IRON.

The forms in which iron occurs in the earth in combination with other substances are very numerous. Nearly all hard rocks, as well as the softer soils, sands, clays, and many "mineral" waters contain iron in some combination and in varied proportions. Iron is seldom found "native"—that is, occurring in the earth in the form of metallic iron. When it is found in the metallic state, as, for instance, in meteorites that have fallen from space upon the earth, it is not in quantities large enough to be of commercial value. The combination of iron with one or more other substances is called an iron compound, or iron mineral, and where the iron compounds are such that iron can easily be extracted from them and they occur in such abundance that they can be mined profitably these iron compounds are called iron ores.

Iron in combination with other substances is regarded next to aluminum, a metal contained in clay, as the most abundant metal. Thus, according to recent calculations,* metallic iron forms about 4.50 per cent of the rock crust of the earth, compared with 7.85 per cent for aluminum.

IRON ORE.

There are four important types of ores of iron—red iron ore, or hematite; brown ore, or limonite; magnetic ore, or magnetite; and carbonate ore, or siderite—although there are hundreds of minerals in which iron is a constituent. These types of ore may easily be remembered through their most common colors, which are, respectively, red, brown, black and grayish.

*Clarke, F. W., The data of geochemistry, 3d ed.; U. S. Geol. Survey Bull. 616, p. 34, 1916.

Hematite.

Hematite includes all varieties of the anhydrous sesquioxide (Fe_2O_3). This is known locally as red hematite, specular ore, gray ore, fossil ore, oolitic ore, etc. Hematite is composed of two parts of the metal iron united with three parts of oxygen. Iron forms 70 per cent by weight of pure hematite and oxygen 30 per cent, and the mineral is known chemically as the sesquioxide of iron or ferric oxide. Hematite may occur as a rock in beds, in veins, or in masses of irregular shape, and it may occur in a soft, earthy state, or as a loose debris in the soil, and yet in all these forms be profitably mined if the controlling conditions are favorable. Hematite is easily recognized in the hand specimen by its colors (red to steel-gray and black) and the red mark or streak it leaves when drawn across a rough surface and by its high specific gravity or superior weight as compared with the weight of pieces of ordinary red rock or red clay of equal size. The old-fashioned "keel" or red chalkstone formerly used by carpenters for marking lumber is a form of hematite. Finely ground hematite is used in the manufacture of red paint and other red coloring materials.

Hematite is by far the most important iron ore. It is found in great abundance in the United States in the vicinity of Lake Superior in Minnesota, Michigan, and Wisconsin; in central New York; in the Appalachian region of Alabama, Georgia, Tennessee, and Virginia; and in eastern Wyoming. It also occurs in lesser quantities in Pennsylvania, Maryland, Kentucky, eastern Wisconsin, Utah, and California. (E. F. B.)

All the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys, being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphree's Valley makes

an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Fort Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than $2\frac{1}{2}$ miles from the outcrop on Red Mountain is not too great for shaft mining.

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They have since sunk a double track slope to the ore. In time this is likely to be the largest producing mine in the State.

Another drill hole was put down in Shades Valley in 1913, in Section 19, T. 19, R. 3 W., but the record was not available for publication at the present time.

The hematite production in Alabama in 1917 was 5,949,096 tons, as against 4,672,005 tons in 1916, an increase of 277,091 tons or 4.89 per cent. The 1917 produc-

tion of hematite is 84.6 per cent of the total iron ore production of the State, and 8.44 per cent of the total iron ore production of the United States.

The average price of hematite in Alabama in 1916 was \$1.52; in 1917, \$1.61.

Brown Ore.

Brown ore is composed of iron, oxygen, and water, and in a general way might be said to be hematite combined with water. A general formula may be expressed by $m\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$. Brown ore may contain water in several proportions so that the percentage of iron likewise varies, but the latter ranges generally from 52 to 66 per cent in the pure mineral. Thus brown ore does not contain quite as high a percentage of iron as hematite, and therefore it can not yield so much metal. One of the most common brown ore minerals is known as limonite ($2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), and this contains 59.9 per cent of iron, 25.7 per cent of oxygen, and 14.4 per cent of water. Brown ore occurs in a large variety of forms, nearly all of which have in common a characteristically yellowish-brown to chocolate-brown color and yield a brown streak and powder. Exceptionally certain hydrated sesquioxides of iron may appear bright red, and some may show black surfaces; but these exceptional forms are generally to be found closely associated with a mass of ordinary brown ore, and familiarity with the deposits soon dispels any perplexity regarding the nature of the ore on the part of persons mining or handling it. The specific gravity of brown ore is also higher than that of ordinary rock. Brown ore commonly occurs in irregular masses and lumps, and as ore gravel and sand, embedded in banks of clay, sand, and stone gravel. The ore in places lies in layers, but more commonly in irregular pockets, separated by barren clay, sand, and stone gravel. In places the ore takes the form of hollow concretions or "pots" which may contain some loose sand or clay in the interior and also it appears as honeycombed masses ramifying through the inclosing ore-bearing ground.

Limonite is used chiefly as a source of iron, but the brown and yellow forms, called ocher, are used for paint

and for making oil-cloth and linoleum. A porous variety of limonite is used in the purification of illuminating gas, and also as a contact material in the production of hydrogen gas for inflation of dirigible balloons and for precipitation of fats from oils. Many iron compounds are used in medicines.

Deposits of brown iron ore are common in many portions of the eastern United States, particularly in valleys underlain by limestone. Some of the best-known deposits are in Connecticut, Vermont, Pennsylvania, Virginia, Tennessee, Alabama, northeastern Texas, and in Iowa and Wisconsin near Mississippi River. (E. F. B.)

This ore, the second in importance in the State, and third in the United States, furnishes only 1.58 per cent of the total iron ore production of the United States, and 15.5 per cent of the iron ore production of the State in 1917. The entire brown ore production of the United States in 1917 was 1,973,096 long tons of which Alabama contributed 1,088,611 tons or 55.2 per cent, and the State holds accordingly the first rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama, commanding the highest prices and a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality

of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be removed for every ton of ore produced, varies very much, not only in the different ore banks, but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The limonite or brown ore production of Alabama in 1917 was 1,088,611 long tons as against 1,075,896 tons in 1916, an increase of 12,715 tons or 1.8 per cent.

The average price per long ton of brown ore marketed in Alabama in 1917 was \$3.08, as against \$1.97 in 1916. (E. A. S.)

Magnetite.

Magnetite (Fe_3O_4) is a black ore of iron which is attracted by the magnet. It contains iron and oxygen in the proportion of 3 parts of iron to 4 parts of oxygen, which by weight gives 72.4 per cent of iron and 27.6 per cent of oxygen. Magnetite thus contains the highest percentage of iron of the ores thus far mentioned, and in fact, of all the iron ores. Magnetite usually occurs in granular form and in crystals in veins in comparatively old crystalline rocks, although it may be found in comparatively young volcanic rock.

Magnetite is found in the United States in considerable quantities in the Adirondack region of New York, the Highlands of New Jersey, south Pennsylvania, eastern Wyoming, central Texas, southwestern Utah, and southern and northern California, and in small quantities in northern Michigan and in other states. It is used chiefly for the production of iron, but the less common variety known as lodestone, which is naturally magnetic, is sold at high prices for museum exhibits and for laboratory purposes. Magnetite is found in the form of sand along streams and on the shores of lakes or seas where it has been concentrated by the action of water. In this form it has not proved of much commercial value as an ore of iron. (E. P. B.)

There has been no development of magnetic ore properly speaking, in Alabama. The gray ore of Talladega County which was mined to some extent a few years ago is essentially a hematite though some of it is slightly magnetic. There was no production of this ore in 1917. (E. A. S.)

Siderite.

Siderite, or iron carbonate (FeCO_3), is composed of 1 part of iron, 1 part of carbon, and 3 parts of oxygen and thus contains by weight where pure, approximately 48.3 per cent of iron, 10.3 per cent of carbon, and 41.4 per cent of oxygen. Iron carbonate ore where fresh is generally grayish in color, and occurs in nodules and in layers principally in sedimentary rocks that contain coal and lignite. The carbonate rapidly changes to brown ore on exposure to moist air. Siderite is known locally as spathic iron ore, kidney ore, clay ironstone, and black-band ore. Certain of these names are derived from the appearance of the ore in its different forms. For instance, a bed of carbonate ore that is found on the top of a coal bed in eastern Kentucky is striped with fine black carbonaceous bands.

Iron carbonate, in addition to being found in Kentucky, is common in southeastern Ohio, and occurs to a small extent in Pennsylvania, Alabama, Mississippi, and Texas.

IMPURITIES IN IRON ORE.

Consideration should be given to some of the principal impurities that are found in iron ores, first, in order to appreciate why a deposit of ore never yields the full percentage of iron that the predominant iron mineral contains, and, second, in order to show the relation of the ore to the operation of the blast furnace. Deposits of iron ore are generally so closely associated with the rocks which inclose them that they contain either mixed with the deposit or chemically combined within it some of the other rock-forming minerals. Among the most common of these minerals are silica, or sand; lime and magnesia, derived from limestone and dolomite; alumina, a clay mineral; manganese, a metal resembling iron; and small quantities of sulphur and phosphorus. The presence of varying percentages of these and other minerals tends, of course, to reduce the percentage of metallic iron that the deposit will yield when mined, and they must be removed as far as possible in mining and almost completely in the process of making iron. Therefore, it is of the utmost importance that the average chemical composition of a deposit of iron ore be ascertained before an attempt is made to mine it.

The average composition may be termed the "quality" of the deposit. The quality is determined chiefly by two men, the prospector and the chemist. The prospector digs trenches and pits or drills holes in the ore and takes samples of it. The chemist analyzes these samples of ore in his laboratory, and finds the percentages of metallic iron, silica, lime, alumina, manganese, sulphur, phosphorus, water, etc., contained in average samples of the ore. On the quality of the ore depend the quantity of fluxing stone and fuel that must be used in the blast furnace and the kind of iron that can be produced.

RANGE IN COMPOSITION.

Many chemical analyses of commercial grades of these iron ores indicate a range in composition given in the following table:

Range in chemical composition of commercial grades of iron ore.

	Hematite Per cent	Brown ore Per cent	Magnetite Per cent	Carbonate Per cent
Metallic iron.....	25-65	35-58	48-70	25-48
Silica.....	2-35	3-23	0.6-20	1-23
Alumina.....	0.2-9	1.4-12	0.7-4.5	1-5
Lime.....	Trace to 27	0-0.6	0.5-4.5	0-7
Manganese.....	Trace to 5	0.16-5	0.07-1.5	0.1-4.7
Sulphur.....	Trace to 1.5	Trace to 0.5	Trace to 1.2	0.01-1.8
Phosphorus.....	0.013-1.23	0.04-1	Trace to 1.75	0.043-0.7
Titanium.....	0-0.9		0-1.5	0-0.04
Water.....	0.3-6	8.8-15	0.25-0.5	0-6.5

Under exceptional conditions ores are mined that contain more or less of the common constituents indicated above, but local conditions may determine whether an ore that falls within the limits shown may be mined. For instance, hematite carrying as little as 20 per cent metallic iron would not be considered of value as an ore unless it contained enough lime to flux the silica and alumina present. Most Southern red hematites contain considerable quantities of lime and are therefore workable where a highly siliceous ore carrying no more metallic iron and little lime would not be available under present conditions of metallurgic practice. At present ores averaging less than 25 per cent of metallic iron are not charged into blast furnaces in any considerable quantities, and ores as lean as this can not be used economically unless they carry more than enough lime to flux them and are used in connection with richer ore. In using limestone as a flux it would probably be more desirable to use a stone carrying 15 to 20 per cent of ferric oxide (10.5 to 14 per cent metallic iron) than one containing only 3 to 5 per cent ferric oxide, on account of the higher iron yield of the former. Nevertheless, the more ferruginous limestone would not commercially be classed as an ore; yet a bed carrying 35.5 per cent ferric oxide (25 per cent metallic iron), although in itself not quite rich enough might be conceded to be an "ore." There are other exceptions to be noted in this table. Some deposits of nontitaniferous magnetite can be so treated by means of crushing and electromagnetic

separation that, although they may contain as little as 25 per cent metallic iron, they will yield a high grade concentrate. Such ores may be used to advantage, especially where they can be concentrated along with richer grades. Considerable phosphorus is present in the mineral apatite associated with Adirondack magnetite; and this and silica are largely eliminated by electromagnetic concentration. The possibilities of various methods of concentration or beneficiation must therefore be taken into consideration in appraising an ore, and this involves consideration of the physical as well as the chemical character of the ore. The content of water is a widely variable item. Some ores contain much absorbed water, which can be driven off by drying. Hematite is found in all stages of hydration, and thus may contain water up to the point where it should really be classed as a brown ore. Hydrated ores are thus concentrated by heating to drive off the chemically combined water. Carbonate ores are calcined to drive off both carbon dioxide and water. Some iron oxides are subjected to a partial reduction and are thus rendered magnetic, and the separation of nonmetallic impurities is thereby greatly facilitated. One brown-ore deposit that averages in the raw state not more than 30 per cent of metallic iron is thus through a complicated process of beneficiation rendered of commercial value. The question of beneficiation is therefore becoming increasingly important; and there must also be taken into consideration the proximity to transportation, and to blast furnaces, to water-power sites for possible electric reduction, as well as the prevailing conditions of the market. The laws of supply and demand that prevail in 1917 make available lower grades of ore than would be considered desirable in times when low prices for iron and steel are current. The question of quantity available is also of importance, for iron ore is so bulky a product, is relatively so low in value even at the best, and involves so large an expenditure for equipment for mining on a satisfactory scale that any deposit should contain several years' supply to be worthy of development.

To summarize, then, the ore should occur in a deposit containing several hundred thousand tons of merchant-

able grades, susceptible of economical mining and convenient to transportation and markets, if its development is to be seriously considered. (E. F. B.)

DETAILS OF IRON ORE PRODUCTION IN ALABAMA,
1916-1917.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and marketed iron ore in 1916 and 1917:

Ore mined in Alabama, 1916-1917, by varieties, with percentage of increase in 1917 in long tons.

YEAR	Hematite	Brown ore	Total Quantity	Percentage of total U. S. Produc'n.
1916	5,672,005	1,075,896	6,747,901	8.99
1917	5,949,096	1,088,611	7,037,707	9.37
Increase	277,091	12,715	289,806	
Percentage	4.89	1.8	4.29	

Iron ore shipped from Alabama mines, 1916-1917.

YEAR	Quantity (Gross tons)	Value
1916	6,801,839	\$10,843,231
1917	7,101,586	13,049,535
Increase	299,747	2,206,304
Percentage	4.4	20.3

Average price per gross ton of iron ore shipped from mines in Alabama and the United States, 1916-1917.

	HEMATITE		BROWN ORE	
	1916	1917	1916	1917
Alabama	\$1.52	\$1.61	\$1.97	\$3.08
United States	2.32	3.12	2.03	2.95

General average, 1916, \$2.34; 1917, \$3.15.

Rank of the first five states in mined and marketed production of iron ore in 1916 and 1917.

1916

Rank	STATE	MINED		MARKETED			
		Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	44,585,422	59.31	45,869,251	58.91	\$106,628,784	58.62
2	Michigan	18,071,016	24.04	18,995,797	24.27	49,054,340	26.97
3	Alabama	6,747,901	8.99	6,801,839	8.61	10,843,231	5.96
4	New York	1,342,507	1.78	1,464,917	1.88	5,571,429	3.06
5	Wisconsin	1,304,518	1.72	1,529,459	1.96	3,644,542	2.00

1917

1	Minnesota	44,595,232	58.4	44,962,127	59.5	\$142,901,148	60.0
2	Michigan	17,868,601	23.4	17,712,916	23.4	62,833,624	25.4
3	Alabama	7,037,707	9.4	7,101,586	9.4	13,049,535	5.48
4	New York	1,304,317	1.7	1,356,011	1.79	7,381,333	3.07
5	Wisconsin	1,202,235	1.57	1,179,709	1.56	3,913,437	1.64

PRINCIPAL IRON ORE MINES.

In 1916 there were 452 iron ore mines active in the United States, and 212 mines in 1917 produced more than 50,000 gross tons of iron ore each, compared with 222 mines in 1916. Of these 212 mines, 11 produced more than 1,000,000 tons of iron ore each in 1917, 1 less than in 1916. First place in 1917 was held by the Hull-Rust mine at Hibbing, Minn.; second place by Red Mountain group near Bessemer, Ala. The production of the Alabama mines producing more than 50,000 gross tons each in 1917 is given below in tabular form.

Iron ore mines of Alabama that produced more than 50,000 long tons each in 1917.

Name of Mine	Nearest Town	Variety of Ore	Quantity
1 Red Mountain Group	Bessemer	Hematite	2,955,022
2 Woodward, Nos. 1, 2 and 3	Lipscomb	Hematite	877,637
3 Songo	Songo	Hematite	283,362
4 Spaulding	Birmingham	Hematite	213,968
5 Raimund, No. 1	Bessemer	Hematite	201,665
6 Steinman	Steinman	Hematite	159,342
7 Attalla	Attalla	Hematite	128,029
8 Greely	Greely	Brown Ore	119,070
9 Hammond	Hammond	Hematite	114,713
10 Ironaton	Ironaton	Brown Ore	84,771
11 Vaney	Russellville	Brown Ore	78,693
12 Raimund, No. 2	Bessemer	Hematite	68,520
13 Tannehill	Goethite	Brown Ore	63,786
14 Friedman	Woodstock	Brown Ore	61,795
15 Houston	Rickey	Hematite	57,151
16 Wilson: Hyde and Hurst	Russellville	Brown Ore	54,029
17 Champion	Oneonta	Brown Ore	51,906

BENEFICIATED IRON ORE.

Statistics of beneficiated iron ore have been gathered by the Survey for the years beginning with 1914 and, although complete returns were not at first received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries have been, on the whole, satisfactory and interesting and have shown continued improvement.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Some of the operations combined two or more of these processes. Iron ores were reported as beneficiated at 94 mines in 16 states in 1917 and at 83 mines in 14 states in 1916.

In Alabama the ore treated was principally brown ore, and the usual processes to which it was subjected were log washing, screening, and picking belt. A total

of 1,159,624 gross tons of beneficiated ore, valued at \$3,324,715, was marketed from 19 mines in Alabama in 1917, compared with 996,344 tons, valued at \$1,969,706, from 12 mines in 1916. Of this quantity 242,742 tons were hematite run over a picking belt.

PIG IRON.

PRODUCTION, SHIPMENTS, AND VALUE, BY STATES.

THE bureau of statistics of the American Iron and Steel Institute reports the production in 1917 of all kinds of pig iron, including such ferroalloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus, produced in blast furnaces as well as some that were electrically produced, as amounting to 38,621,216 gross tons, compared with 39,434,797 tons produced in 1916, a decrease of 813,581 tons, or about 2 per cent.

*Pig iron, including some ferroalloys, manufactured in the United States in 1916 and 1917, in gross tons.**

	1916	1917		1916	1917
Pennsylvania	16,506,284	15,539,728	Virginia	399,885	520,311
Ohio	8,602,895	8,518,603	Missouri		
Illinois	3,922,512	3,456,915	Iowa†		
Alabama	2,762,885	2,953,705	Colorado	437,633	453,742
Indiana			Washington		
Michigan	2,221,708	2,657,503	California		
New York			Maryland	501,452	422,212
New Jersey	2,352,535	2,417,527	Tennessee	355,374	369,951
Wisconsin			Connecticut		
Minnesota	811,325	738,541	Massachusetts	5,719	10,527
West Virginia					
Georgia	554,590	561,951		39,434,797	38,621,216
Kentucky					

*Bureau of statistics of the American Iron and Steel Institute.

†Ferrosilicon produced in electric furnace for first time in 1916.

Pig iron shipped from blast furnaces in the United States in 1916 and 1917.

STATE	1916		1917		Change in 1917		Percentage change, 191	
	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity	Value
Alabama	\$2,672,498	38,994,660	2,971,626	\$64,309,714	+	299,128	+	\$25,315,054
Illinois	3,857,391	67,764,309	3,458,126	91,094,541	—	399,265	—	23,330,232
Kentucky	144,444	2,595,600	192,204	5,532,367	+	47,760	+	2,936,767
Michigan	505,646	8,851,361	611,446	18,300,501	+	105,800	+	9,449,140
New Jersey	*	*	187,753	6,618,536	†	†	†	†
New York	2,289,608	40,537,240	2,276,367	52,318,661	—	13,241	—	11,781,421
Ohio	8,889,030	136,855,228	8,469,052	231,165,093	—	219,978	—	94,309,865
Pennsylvania	16,351,131	293,437,782	15,423,262	460,677,474	—	927,869	—	167,239,692
Tennessee	329,342	4,981,538	346,638	9,102,441	+	17,296	+	4,120,903
Virginia	444,491	7,140,002	562,299	15,703,295	+	117,808	+	8,563,293
Wisconsin	423,973	7,534,327	402,732	11,032,274	—	21,241	—	3,497,947
Other states†	3,418,770	54,786,071	3,711,041	87,931,078	+	†480,024	+	†39,763,543
	39,126,324	663,478,118	38,612,546	1,053,785,975	—	513,778	—	390,307,857
							1.3	59

*Included with "Other States."

†Increase in New Jersey included in "Other States."

‡1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia. 1917: Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, Washington, and West Virginia.

AVERAGE PRICES.

The average price per gross ton of all kinds of pig iron, by states, from 1912 to 1917, given in the following table is based on reports of the manufacturers to the Survey. These figures represent the approximate prices f. o. b. at the blast furnaces and do not include the prices of ferroalloys.

The general average prices for 1916 and 1917 appear low for such active years in the iron industry. At the close of 1916 market prices of pig iron were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year, so that the average increase in price was only 28 per cent as compared with 1915. In 1917, however, the course of prices was very different, for at the beginning and end of the year prices were more nearly the same with the high levels at the middle of the year. The curve of market price of basic iron at Valley furnaces reflects this unusual condition. The general average prices for all grades of pig iron at the furnaces, exclusive of ferroalloys, for the year 1917 was \$27.29, as compared with \$16.96 in 1916, an increase of \$10.33 a ton, or nearly 61 per cent. The states in which the average selling price of pig iron was more than \$30 a ton were Connecticut, Georgia, Massachusetts, Missouri, New Jersey, and Washington.

*Average price per gross ton of pig iron in the United States,
1912 to 1917.*

STATE	1912	1913	1914	1915	1916	1917
Alabama	\$10.75	\$12.08	\$10.52	\$10.24	\$14.59	\$21.64
Illinois	15.26	15.83	13.59	13.93	17.57	26.34
Kentucky	15.74	16.09	12.24	13.44	17.97	28.78
Michigan	14.30	14.69	13.78	13.63	17.51	29.93
New Jersey	*	*	*	*	*	35.25
New York	14.22	15.35	14.26	14.02	17.70	22.98
Ohio	13.07	15.02	13.46	12.96	15.75	27.30
Pennsylvania	14.60	15.36	13.78	13.69	17.95	29.87
Tennessee	12.29	13.22	12.05	12.09	15.13	26.26
Virginia	13.27	13.96	12.53	12.83	16.06	27.93
Wisconsin	14.33	15.13	13.35	13.20	17.77	27.39
Other states†	14.07	15.50	13.55	12.96	16.03	24.25
Average for United States	13.93	15.08	13.42	13.21	16.96	27.29

*Included in "Other States."

†1911: California, Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1912 and 1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1917: Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, Washington, and West Virginia.

BLAST FURNACES.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1916 and 1917, not including any electric reduction furnaces, as published by the bureau of statistics of the American Iron and Steel Institute, are as follows:

Blast furnaces in the United States, 1916 and 1917.

STATE	Furnaces in blast June 30, 1916.	Dec. 31, 1917			Furnaces in blast June 30, 1917.	Dec. 31, 1917		
		In.	Out.	Total.		In.	Out.	Total.
Pennsylvania	132	127	30	157	136	122	41	163
Ohio	67	65	12	77	72	64	15	79
Illinois	23	24	0	24	22	18	7	25
Alabama	31	29	18	47	34	34	13	47
New York	20	18	9	27	21	21	4	25
Virginia	9	9	13	22	12	15	4	19
Tennessee	12	11	7	18	12	10	6	16
Colorado	4	3	3	6	4	3	3	6
Missouri	1	2	0	2	2	2	0	2
Oregon	0	0	1	1	0	0	1	1
Washington					0	0	1	1
California	0	0	0	0	0	1	1	1
Maryland	4	4	1	5	4	2	3	5
New Jersey	1	1	4	5	4	5	0	5
Wisconsin	6	5	3	8	6	5	3	8
Minnesota	3	3	0	3	3	3	0	3
Indiana	10	10	0	10	12	13	1	14
Michigan	12	12	2	14	12	12	2	14
West Virginia	4	4	0	4	4	3	1	4
Kentucky	4	4	2	6	4	4	3	7
Georgia	0	0	4	4	0	1	3	4
Texas	0	0	2	2	0	0	2	2
Mississippi	0	0	1	1	0	0	1	1
Connecticut	0	1	2	3	2	2	1	3
Massachusetts	1	1	1	2	1	1	1	2
	344	333	115	448	367	340	117	457

LIME.

DURING the year 1917 there was a decrease in the production of lime in Alabama, as compared with the production of the preceding year. The total product of 10 plants in 1917 was 66,744 short tons, a decrease from 1916 of 780 tons, or 1.2 per cent.

The value of the product was \$383,211, an increase of \$70,680 or 22.6 per cent.

The most important use of the lime produced was for building purposes, 60.5 per cent of the product is definitely so credited in the returns while the greater part of the lime sold to dealers and most of the hydrated lime go to building purposes. Other chief uses of lime are in chemical works, paper mills, sugar factories, agriculture, tanneries, slag cement, etc.

Shelby County, as heretofore, was the largest producer in 1916, being credited with 52,809 tons or 78.21 per cent of the total. The other producing counties in the order of their importance are Blount and Jackson.

The following tables give some additional data on the lime production in Alabama in 1916 and 1917.

For a full account of the lime industry in the United States, those interested are referred to the article on Lime, by G. F. Loughlin, in "Mineral Resources of the United States, 1917."

Lime burned and sold in Alabama in 1916 and 1917.

YEAR	Rank of state by quantity	Quantity (short tons)	Value	Rank of state by value	Average price per ton	Number of plants in operation
1916	16	67,524	\$312,531	23	\$4.63	9
1917	16	66,744	383,211	17	5.74	10
Incr'se or decrease		— 780	+ 70,680		+ 1.11	
Percentage		— 1.2	+ 22.6		+ 24.0	

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Lime sold in Alabama in 1916 and 1917, by uses.

	Quantity (short tons)	Value	Average price per ton U. S.
1916			
Building lime	7,744	\$33,069	\$5.21
Chemical works	703	2,571	3.70
Paper mills	†	†	4.14
Sugar factories			5.41
Tanneries	†	†	4.64
Agriculture	592	2,246	3.63
Dealers, uses not specified.....	50,007	243,582	4.95
Other uses, and undistributed.....	8,478	31,063	
Total.....	67,524	\$312,531	\$4.54
1917			
Building lime	40,336	237,410	\$6.63
Chemical works	3,222	16,503	5.79
Paper mills	7,600	35,968	5.65
Sugar factories	1,210	7,459	8.03
Tanneries	†	†	6.14
Agriculture	1,791	9,816	5.07
Dealers, uses not specified.....	11,290	69,879	6.42
Other uses and undistributed.....	†	†	9.09
Total.....	66,744	383,211	6.29
Percentage of increase or decrease in 1917.....	— 1.2	+ 22.6	
Hydrated lime (included in total), 1916.....	6,780	36,864	
Hydrated lime (included in total), 1917.....	6,541	48,089	
Increase or decrease of hydrated lime in 1917.....	— 239	+ 11,225	
Percentage of increase or decrease of hydrated lime in 1917.....	— 3.63	+ 30.6	

Lime consumed in Alabama in 1917.

LIME, 1917					Consumption of Lime per capita (short tons)		
Produced (short tons)	Consumed		Shipped out of State (short tons)	Shipped into State (short tons)	1916	1917	Population in 1917 (estimated)
	Quicklime (short tons)	Hydrated lime (short tons)					
66,744	20,026	2,895	47,426	3,603	0.01	0.01	2,363,939

Number of lime kilns in Alabama using various kinds of fuel in 1916 and 1917.

	Coal	Wood	Oil	Natural gas	Producer gas	Coke	Shavings	Coal and Wood	Coal and Coke	Total
1916	7	6						20		33
1917	4	1						12		17

KILNS.

By W. E. EMLEY.

The accompanying table contains evidence of a certain amount of confusion in the common usage of the names applied to different types of limekilns. It was thought advisable to include kilns called "shaft," "vertical," "continuous," or "gas" in the column headed "flame or patent kilns," assuming these all to be different names for the same thing. It is possible that this assumption may be incorrect.

In order to avoid such confusion in the future, and for the broader purpose of establishing a system of nomenclature within the industry, the following definitions of the different types of kilns are suggested:

A "field" kiln is distinguished from all other types by being intermittent in its operation. Firing is continued until the contents of the kiln are calcined, when the kiln is entirely emptied. Under some conditions it may be demolished and rebuilt after each burn. A "continuous" kiln is a kiln of any type other than a field kiln.

A "pot" kiln is a vertical shaft kiln which is continuous in its operation. Its peculiar characteristic is that the fuel and stone are charged into the kiln in alternate layers.

A "flame" kiln is a vertical kiln which is continuous in its operation. Its name is derived from the fact that only the flame of the fuel and not the fuel itself comes into contact with the stone or lime. This type is sometimes known as a "patent" kiln, but the term "flame" is to be preferred as more significant.

A "rotary" kiln needs no description.

The term "gas kiln" is to be avoided in this connection because it indicates the kind of fuel rather than the type of kiln.

Capacity and kind of lime kilns used in Alabama in 1917.

Capacity (short tons per day)	Pot	Flame	Rotary	Field and Unspecified	Total
317	9	14			23

MICA.

By WALDEMAR T. SCHALLER.

INTRODUCTION.

MICA is used in the form of sheet mica, splittings, and ground mica. The uncut sheet of smallest practicable size, known as punch mica, should yield a disk or washer at least $1\frac{1}{2}$ inches in diameter if the mica is stained and $1\frac{1}{4}$ inches in diameter if the mica is clear. The smallest "plate sheet" should yield a rectangle at least $1\frac{1}{2}$ by 2 inches. Sheet mica is used in various sizes, chiefly for insulation in electric appliances, for glazing the fronts of stoves, for lamp chimneys and shades, and for phonograph diaphragms. Both domestic and foreign mica are used for these purposes. For certain high-potential electric appliances only a high-grade mica free from inclusions, cracks, pin holes, or other defects, can be used.

Splittings or films are very thin sheets of mica, about a thousandth of an inch thick. These are manufactured into built-up mica boards, such as micanite, micabeston, micabond, and micadamite. No appreciable quantity of splittings or films of domestic mica is sold, practically

the entire supply of splittings consumed in the manufacture of mica board being imported. This built-up mica board is largely used in electric insulation.

Ground mica finds its chief applications in the manufacture of patent roofing, in the annealing of steel, in lubrication, and in decoration. These and other uses are described in detail below. Although some ground mica is imported, the bulk of such mica consumed, about 96 per cent, is of domestic origin. Mica has been estimated to constitute about 4 per cent of all igneous rocks, and as no special property is required of mica suitable for grinding, it is evident that any desired quantity of ground mica can be produced in this country.

The requirements for sheet mica to be used in the industries are very particular, and only a very small percentage of the total mica extracted can finally be utilized as sheet. The specifications for mica to be used in high-potential appliances, such as are used in wireless apparatus and in airplanes and automobile trucks, are very rigid.

Owing to the restrictions imposed on the importation of mica the question has arisen whether the entire demand of the country can be supplied by the domestic production. This question can not be definitely answered at present, but there seem to be grave doubts as to the domestic output being sufficiently increased.

The sheet mica imported from India has been largely used in many industries in this country and has been generally found to give very satisfactory results. Much of the domestic mica produced is said to be unfit for many of the purposes to which Indian mica is applied. An inquiry as to the possibility of domestic mica replacing imported Indian mica must have reference to the quality of the domestic mica and the quantity of suitable material which can be produced. Several large users have stated that this country contains deposits of mica which is fully as good as the Indian mica.

For the 18-year period 1900-1917 the proportion of the consumption of sheet mica (including splittings) represented by domestic production has averaged about 38.5 per cent, with extreme variations of 14 per cent in 1902 and 64 per cent in 1908. The average for 1900-1913

was 38 per cent. For the years 1903-1907, 1909, and 1912-1917 the percentages lay between 30 and 50. For the war years the percentages have shown very little change, being 41 for 1914, 40 for 1915, 40 for 1916, and 42 for 1917. In other words, there has been very little change in the ratio of domestic production to consumption of sheet mica since 1913. This ratio shows a decrease, however, as compared with the years immediately preceding 1914, except 1912, for the percentages were 44 for 1913, 30 for 1912, 59 for 1911, 56 for 1910, 49 for 1909, and 64 for 1908. For the years 1900 to 1907 the percentage was lower than 38 each year.

PRODUCTION.

The domestic production in 1917 came from eight states, which, grouped in the order of quantity of sheet mica produced, are North Carolina, New Hampshire, Virginia, South Dakota, Georgia, Alabama, Idaho, and Colorado. As in previous years, North Carolina led all other states both in quantity and in value of mica produced.

Percentage of production of mica in 1917, by States.

STATE	Quantity		Value
	Sheet	Scrap	
North Carolina	48	67	70
New Hampshire	39	20	23
Virginia	6	8	3
South Dakota	3	5	1
Georgia	1		
Alabama		4	3
Idaho and Colorado			
	100	100	100

The annual production of mica in Alabama for the years 1912-1917 is shown in the following table. Where less than three producers reported returns, the figures are omitted, so that no individual production is disclosed. For several years, therefore, the figures of production can not be given.

Mica produced by Alabama, 1912-1917.

YEAR	SHEET MICA			SCRAP MICA		Total quantity (short tons)	Total value
	Quantity (pounds)	Quantity (short tons)	Value	Quantity (short tons)	Value		
1912	0	0	0	0	0	0	0
1913	*	*	*	*	*	*	*
1914	32,900	16	3,964	0	0	16	3,964
1915	8,400	4	5,545	23	395	27	5,940
1916	14,132	7	4,955	65	660	72	5,615
1917	18,476	9	3,528	0	0	9	3,528

PRICES.

Average prices per pound paid in the South for rough-trimmed sheet mica of good quality, split and sorted to cut the sizes indicated, 1913-1917.

SIZE (IN INCHES)	1913	1914	1915	1916	1917
Punch	\$0.035	\$0.03	\$0.04	\$0.05	\$0.055
1½ by 2	.12	.10	.20	.30	.40
2 by 2	.30	.25	.40	.55	.70
2 by 3	.70	.65	.70	.90	1.10
3 by 3	1.15	1.00	1.00	1.35	1.55
3 by 4	1.35	1.20	1.25	1.70	1.85
3 by 5	1.70	1.50	1.50	1.95	2.15
4 by 6	2.25	2.00	2.10	2.85	3.10
6 by 6	3.00	2.70	2.80	3.50	3.80
6 by 8	4.00	3.60	3.50	5.00	4.70
8 by 10	6.00	5.40	5.20	7.50	7.50

Average prices paid in the South per pound for rough-trimmed sheet mica, split and sorted to cut the sizes and qualities indicated, December, 1917-January, 1918.

SIZE (IN INCHES)	Good quality	Slightly spotted, or clay-stained	Heavily spotted or clay-stained
Punch	\$0.07	\$0.06	\$0.05
1½ by 2	.45	.35	.20
2 by 2	.80	.65	.35
2 by 3	1.25	1.00	.65
3 by 3	1.60	1.40	.90
3 by 4	1.90	1.60	1.20
3 by 5	2.25	1.90	1.40
4 by 6	3.25	2.50	1.75
6 by 8	5.00	3.75	2.25

USES.

The different uses to which mica is put depend on its form—whether in sheets or in powder. Sheet mica is used in the electrical industry, for glazing, and to some extent for other purposes. Ground mica is used chiefly in the decorative trades, for annealing, for lubrication, and in patent roofing.

Sheet mica finds its greatest use in the electrical industry, where an insulating, noninflammable material is necessary. It is used in sheets and as washers and disks in dynamo-electric machinery, electric-light sockets, spark plugs, insulators, guards in rheostats, fuse boxes, and telephones. Flexible cloth and tape, covered with mica, find varied uses in electrical apparatus. Sheet mica is used for glazing the fronts of stoves, for furnace sight holes, for screens in front of highly heated material, for optical lanterns as a retarder of heat waves, and for making lamp chimneys and lamp shades. It is also used in spectacles (amber-colored phlogopite* would seem to be the ideal material for goggles in oxy-acetylene weld-

*Thin sheets of phlogopite, if of suitable clearness and color, afford very great relief to the eyes in glaring sunlight and seem to make objects more clearly visible.

ing), motor goggles, sand blasting, sight holes of divers' helmets and smoke helmets, compass cards, automobile shields, phonograph diaphragms, in windows where glass would be broken by heavy shocks or by vibrations as in the conning towers of warships and of submarines, and in lantern transparencies.

A peculiar silvery mica is used in India for inlay work. In India also pictures and portraits in large numbers are painted on sheets of mica.

Sheet mica has come to be of importance as a war mineral through its use as insulator in electric apparatus, especially in condensers, magnetos, and spark plugs; also as windows in masks worn for defense against asphyxiating gases, and for other uses where a transparent, non-inflammable, nonshattering material is necessary, as in automobile goggles and as coverings for wounds.

Ground mica is used for decoration in wall paper, to which it gives luster and brightness; in fancy paints, ornamental tiles, concrete, rubber goods, pipe and boiler coverings, insulating compounds, fire-proof paints and coverings, patent roofing material, molded mica (ground mica mixed with shellac), and calico printing; as absorbent for nitroglycerin in the manufacture of "mica powder;" in annealing steel; to a large extent as a lubricant for wooden bearings, or, mixed with oil, as a lubricant for wooden bearings, or, mixed with oil, as a lubricant for metal bearings; in the manufacture of automobile treads on new tires, as well as in repair stock; and as a filler for various other products. Tar and other roofing papers are coated with coarsely ground mica to prevent sticking when they are rolled for shipment. A possible value of ground mica as a chemical source of potash salts has been suggested, especially its direct application to the soil as a fertilizer.

A recently patented insulating material,[†] claimed to be hard and almost incombustible, is composed of 14 per cent sifted mica, 52 per cent pulverized asbestos, 20 per cent mineral caoutchouc, 10 per cent rubber solution, 3 per cent sulphur, and 1 per cent resin. The material can be molded and wrought and can be used as a substitute

[†]Jour. Indust. Eng. Chemistry, vol. 10, p. 314, 1918.

for porcelain, marble, slate, and vulcanized substances.

In India ground mica is used for processional ornaments, such as lamps, pottery, curtains, cloth, and tinsel decorations on fans, and in buildings, especially in temples and palaces. Large quantities have also been employed for medicinal uses—an application which has not extended beyond its country of origin.

Several trade names have been given to the mica products described below.

Micalite is applied by Eugene Munsell & Co., 68 Church Street, New York, N. Y., to the mica used in mica chimneys, candle shade protectors, and canopies.

Micanite is a term applied by the Mica Insulator Co., of Schenectady, N. Y., to a manufactured mica board or plate, built up by successive layers from many small thin films of mica, which, after being dipped into and cemented with shellac, are then subjected to pressure under heat to dry out the shellac. These large sheets are then milled to the requisite thickness and made suitable for many electrical purposes.

Micabeston, which is similar to micanite, is manufactured by the American Mica Co., of Newton Lower Falls, Mass. Several varieties are made, one of which becomes flexible when heated and rigid when cold, and is used for insulation in field coils, transformers, armatures, etc., where high heat is not generated, another variety remains rigid under a high heat and is used in commutators of generators and motors.

Micabond, made by the Chicago Mica Co., of Valparaiso, Ind., is also similar and is made in varying qualities with different properties, depending on its use.

Micadamite, manufactured by Mierowsky Bros., 106-108 Broadway, Jersey City, N. J., is similar built-up mica-plate, manufactured into rings, tubes, segments, and many other forms of insulation.

These manufactured mica sheets use a number of different substances as binders in addition to shellac, chiefly paper of various grades (Japan tissue, manila, rope, fish), muslin cloth, rubber, and gutta percha.

Silberglimmer (silvery mica) is muscovite which has been heated to a sufficiently high temperature to make it

softer and opaque and silvery in appearance. It is also known as annealed mica and finds a use in certain parts of electric apparatus.

Rimco is mica ground by a nonmetallic process by the Richmond Mica Co., Richmond, Va., for use as a tire powder. It is also used by manufacturers of oils and lubricating greases.

Micamima, prepared by the Crawford Mica Co., of Crawford, Nebr., is a coarsely ground mica used in the manufacture of concrete facing material; mixed with other minerals it is used to give the effect of natural rock, and it may be used for different decorative purposes.

Micolith, or micholithic, prepared by the Texas Mica Co., of Pecos, Tex., is another similar product used to give the effect of natural rock to concrete facings.

Tungash, as the Denver Mining & Manufacturing Co., of Denver, Colo., calls its product, is a bronze-colored, metallic-looking material of value for decoration. The crude biotite mica, altered and hydrated, has a dull greenish-black appearance when mined. On being heated it expands to a light product, which has a rich golden-bronze color and a decidedly metallic luster.

Clinomica is the name given by the America Mica Co., 52 Broadway, New York, to its ground clinocllore, a micaceous mineral of the chlorite group. Clinomica possesses essentially the qualities of ground mica and is used as a dusting material in the rubber and composition-roofing industries, for paints, cements, lubricants, molded electric insulation, and as a filler for various products.

MINERAL WATERS.

By ARTHUR J. ELLIS.

CHARACTER OF STATISTICS.

THE statistics given in this report have been compiled from individual reports furnished by the owners or operators of springs and include, so far as can be ascertained, only natural waters that are bottled and sold in

their natural state or only slightly altered from their natural state. Natural still waters that have been artificially carbonated, natural carbonated waters that have lost part of their carbon dioxide, and waters from which iron has been removed are included; but artificial waters and natural waters that have been flavored, concentrated, fortified, diluted, or otherwise essentially modified in chemical character are excluded if available information indicates such treatment. Water given away or consumed at spring resorts, which constitutes a large part of the annual production, is excluded. Waters sold at flat or meter rates, delivered to consumers through pipes, or otherwise obviously municipal supplies or adjuncts to them are excluded. This is the nearest practicable conformity with the commonly accepted definition of natural mineral water. No distinction is made between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well. Many of the best-known mineral waters in the United States come not from natural springs but from wells.

Distinction for statistical purposes between table and medicinal waters is entirely arbitrary. Most table waters are clear, sparkling, and without distinct mineral taste or odor; many medicinal waters are highly mineralized and have distinct mineral taste and odor. Yet some table waters are more strongly mineralized than some medicinal waters, and many medicinal waters contain less mineral matter than certain city supplies. The basis here used for distinguishing medicinal from table waters is the report regarding the spring, and this distinction is based in turn on the operator's knowledge that some of his customers buy the water to use regularly on their tables and others buy it for an aid during illness. A few strongly mineralized waters are not sold as table waters, and a few widely sold table waters are not used medicinally, but many waters are sold for both uses, though the reported sales of several medicinal waters have distinctly decreased in the last few years.

MINERAL WATER TRADE IN ALABAMA, 1917.

Returns from Alabama indicate that the mineral-water trade in 1917 was about 46 per cent less than it was in 1916. The sales amounted to 56,270 gallons, and the value of the output was \$5,509, the average price per gallon decreasing from 12 cents to 10 cents. There was a considerable decrease in the value of the output of table waters, from \$6,195 to \$2,072. Two springs which were active in 1916 reported no sales for 1917; one which was active in 1916 was not heard from, and another, from which no report was received, was estimated. Three mineral-water bathing establishments and 5 resorts, accommodating about 500 guests, were maintained. The quantity of mineral water used in the manufacture of soft drinks decreased from 13,500 gallons to 1,227 gallons.

The following 13 springs reported sales:

Bladon Springs, Bladon Springs, Choctaw County.
 Blount Springs, Blount Springs, Choctaw County.
 Cooks Springs, Cooks Springs, St. Clair County.
 Dixie Springs, Dixie Springs, Walker County.
 Gordon Mineral Springs, Canoe, Escambia County.
 Healing Springs, Healing Springs, Washington County.
 Livingston Mineral Well, Livingston, Sumter County.
 Luverne Mineral Spring, Luverne, Crenshaw County.
 McCary Mineral Well, near Birmingham, Jefferson County.
 Matchless Mineral Water Well, east of Greenville, Butler County.
 Purity Spring, Spring Hill, Mobile County.
 Shocco Springs, Talladega, Talladega County.
 White Sulphur Wells, near Jackson, Clarke County.

The following tables add some details to the general statements above given:

Mineral waters sold in Alabama in 1916 and 1917.

YEAR	Commercial Springs	Quantity Sold (gallons)	Average price per gallon (cents)	Value of medicinal waters	Value of table waters	Total value
1916	16	103,944	12	5,979	6,195	12,174
1917	13	56,270	10	3,437	2,072	5,509

Comparative production of mineral waters in Alabama in 1916 and 1917.

YEAR	Commer- cial Springs	Quantity sold (gallons)	Value of product
1916	16	103,944	\$12,174
1917	13	56,270	5,509
Decrease	— 3	— 47,674	— 6,665
Percentage of decrease	— 18.7	— 46.8	— 54.7

A comparison of American and European mineral waters, by Alfred A. Chambers, is given in "Mineral Resources of the United States, Part II, pages 500-508." A discussion of the waters of Alabama, may be found in a report of the Geological Survey of Alabama, "Underground Waters of Alabama," by Eugene A. Smith, State Geologist, 1907.

PYRITES.

QUALITIES AND USES.

THE term pyrites is the indefinite general trade name for any of the iron sulphide minerals, such as pyrite, marcasite, and pyrrhotite. Pyrite and marcasite when pure have identical chemical composition, namely, about 53 per cent sulphur and 47 per cent iron, but differ from each other in mode of crystallization. Pyrite forms cubical crystals, whereas marcasite forms tabular crystals. Pyrrhotite when pure contains about 40 per cent sulphur and 60 per cent iron, it is somewhat softer, tarnishes more readily than either pyrite or marcasite, and is magnetic, whereas the other minerals are not.

Pyrites is used mainly for the manufacture of sulphuric acid, and more than 1,250,000 long tons is consumed each year for this purpose. Pyrites, as commercially used, is generally referred to one of two classes,

lump or fines. The lump ore, as its name implies, consists of pieces more than half an inch in diameter, with a certain allowable proportion of smaller particles, and is used in the condition in which it comes from the mine with little more than a preliminary crushing and sorting according to size. The fines consist of smaller particles and generally have been obtained by crushing the ore so small that the pyrites can be separated from worthless gangue by some mechanical process. They are also derived from ore that has disintegrated as a result of leaching. Owing to the different methods of treating these two kinds of pyrites for the extraction of their sulphur, they can not be used interchangeably. The lump ore commands somewhat higher prices than the fines, but, of course, it is more difficult to obtain a lump ore with as high a sulphur content as that of fines. As a result, only a few mines or parts of a mine can furnish lump ore and maintain a sufficient sulphur content, whereas suitable fines may be obtained even from deposits in which the pyrites is sparsely disseminated.

No definite lower limit can be placed on the proportion of sulphur that a pyritic ore must contain to be of commercial grade. In practice, however, material containing more than 40 per cent of sulphur is specified, and practically none of the acid companies use material that carries less than 35 per cent of sulphur.

Several elements or substances by no means rare in pyritic ores are objectionable as material to be used in the manufacture of sulphuric acid and decrease the value of the ore in which they occur, or they can be used only by means of special treatment.

Certain elements, arsenic and antimony for instance, are poisonous and have a bad effect on the resulting acid, but some of the large fertilizer plants do not reject an ore containing less than 1 per cent of arsenic. These elements are also injurious from a manufacturing standpoint if the pyrites is used in plants making acid by the contact process, as they attack the platinum and cause it to lose its efficiency. According to Wilson,* pyrites carry-

*Wilson, A. W. G., Pyrites in Canada: Canada Dept. Mines, Mines Branch, Pub. 167, p. 22, 1912.

ing more than 8 per cent of copper can not be profitably employed in the manufacture of sulphuric acid. Carbonaceous material, such as the coal adhering to the pyrites or "coal brasses," is apparently heavily penalized by acid manufacturers because it yields acid of a dark color. This effect, however, should not prevent pyrites containing some material of this sort being used in making some low-grade acids for the manufacture of fertilizers and similar materials. On the other hand, however, most of the pyrites derived from the coal beds is marcasite, which decomposes readily, sometimes ignites through spontaneous combustion, or oxidizes to sulphuric acid, and is therefore a dangerous or expensive substance to leave in storage dumps.

CONDITION OF THE INDUSTRY.

The pyrites industry throughout 1917 showed an unsettled condition due largely to uncertainty as to whether importation of foreign pyrites would be continued. At times the impression would be prevalent that further imports of pyrites would be stopped and there would follow a feverish interest in finding possible sources of domestic ore. Before much progress had been made in this search, however, a contrary rumor would be circulated and activities would decrease or actually stop. These conditions alternated in their hold on the minds of those who might have been willing to undertake the rather expensive and time-consuming operation of developing mines capable of supplying the sulphuric-acid industry with pyrites. Because of this uncertainty some of the former users of imported pyrites decided to replace it with sulphur and thus reduce the quantity of imported ore required. This substitution required little change in technology in many of the plants and it was adopted by many manufacturers. By the last part of the year, however, it became evident that more domestic pyrites was necessary, and consequently several mines were opened. It takes time, however, to bring a pyrites mine to the producing stage, so that this activity had but little effect on the output of pyrites in 1917, but it will probably have a considerable effect on the output in 1918.

The shortage of pyrites was made evident by the high price that was paid for it and the difficulty of obtaining considerable quantities even at prices three times those paid in 1916. The quotations given for pyrites in the technical press in 1917 range all the way from 20 to 35 cents a unit for the sulphur content. On the assumption that the pyrites carried 45 per cent sulphur, the latter price would bring a return of \$15.75 a ton for the pyrites. The usual pre-war price of pyrites was less than \$4 a ton, and according to the statistics published by the Geological Survey the average price per ton even in 1916 was \$4.64.

Pyrites produced in United States in 1917.

	Quantity (long tons)	Value		Quantity (long tons)	Value
California	115,817	\$333,501	Virginia	170,382	\$1,378,043
Georgia	23,242	155,560	Other states*	115,407	498,776
Illinois	24,596	89,998			
Ohio	13,218	29,557		462,662	2,485,435

*Includes Alabama, Indiana, Kentucky, Missouri, New York, Pennsylvania, South Dakota, Tennessee, and Wisconsin.

PRODUCTION IN ALABAMA.

In 1917 there were three producing pyrites mines in Alabama—those of the National Pyrites & Copper Co., the Southern Sulphur Ore Co., and the L. M. Mining Association. All three of these mines are in the east-central part of the State, in Clay County, near Pyriton. Deposits in this region have been known for some time, but the mines were reopened during 1917, and by the end of the year the first two were producing a considerable quantity of pyrite.

The deposit at the National Pyrites & Copper Co.'s mine, formerly owned by the Alabama Sulphur Ore & Copper Co., is in schist and consists of irregular lenses, some of them 300 feet long and 35 feet thick. The deposit has been opened by an incline of about 30° slope for a distance of 450 feet, and the average grade of ore

shipped is reported to carry about 40 per cent sulphur. Both lump and fines are shipped. The ore also carries about 1 per cent copper.

The conditions at the property of the Southern Sulphur Ore Co.'s mine are essentially the same as at the National Pyrites & Sulphur Co.'s mine, and both lump and fines, containing about 40 per cent of sulphur, are shipped.

The L. M. Mining Association has leased the old Mat-tison mine, about 2 miles from Pyriton. The ore body is reported to have an average thickness near the surface of about 8 feet, but this decreases in depth so that at the bottom of the shaft, which is 135 feet deep, it is only about 2 feet thick. The ore is reported to have an average content of 42 per cent of sulphur and more than 2 per cent of copper.

All three of these mines report great difficulty in getting an adequate supply of suitable labor. It is estimated that possibly during 1918 they may have a combined production of 25,000 tons.

The general belt in which the ore bodies described occur extends for a considerable distance beyond the area prospected and seems to be worth further investigation. In Coosa County, on Hatchet Creek near Bull Gap, and at the old McGhee gold mine, some pyritic ore has been mined in the past, and probably a small quantity could be quickly obtained if required and possibly a considerable output if systematic exploration and development were undertaken. According to the State geologist of Alabama, however, the pyrites at the Hatchet Creek locality is in irregular concretionary masses and consequently is probably of rather small extent.

A large deposit of what appears to be bedded limonite derived from pyrites is reported in Shinbone Valley, 10 to 15 miles northeast of Pyriton. This appears to be a gossan and if so it is worth testing with the drill, as the indications point to a considerable deposit of pyrites beneath it. W. S. Harper, of Wedowee, Ala., owns some of the properties on which this deposit occurs. Near Stonehill, in Cleburne County, in the vicinity of the Woods copper mine, are two deposits of pyrrhotite and

pyrite. The ore is in general similar to that in the Ducktown district, Tenn., and the deposit at one of the localities is said to have been traced more or less continuously for a distance of 1,200 feet. An analysis of the ore is reported to have shown a content of slightly more than 30 per cent of sulphur.

Numerous reports have been received of indications of pyrites all the way from Chilton County west of Coosa River northeastward to the Georgia-Alabama State line, but details concerning promising localities are not at hand. Some pyrites has been reported near Gold Branch, in Coosa County, also along the eastern flanks of Talladega Mountain, at the old Hog Mountain gold mine, where a vein of pyrites 10 to 15 feet thick has been reported. H. D. McCaskey, of the United States Geological Survey, also noted an apparent gossan at least 30 feet wide and possibly 50 feet wide on the south flank of Horseblock Mountain near the Chulafinnee-Abel road. This type of material trends about east and west and outcrops of it or of similar deposits have been recognized for a distance of about 2 miles. The eastern outcrop has been prospected for copper in the past but without success.

SILICA.

SILICA was produced by one firm operating at Tredegar, Calhoun County, Alabama, in 1917. The material quarried is a soft siliceous residue somewhat like the tripoli mined in Missouri and Illinois.

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1917 was 476,678 short tons, valued at \$222,011, as compared with 726,650 tons, valued at \$184,216 in

1916, a decrease in quantity of 249,972 tons, or 34.2 per cent, and an increase in the value of \$37,795, or 20.3 per cent.

There was a decrease in the quantity of sand of 272,044 short tons, or 43.2 per cent, and in the value of \$8,277, or 5.59 per cent.

There was an enormous increase in the production of gravel. The increase in quantity was 22,072 short tons, or 22.7 per cent, and of \$46,072, or 126.1 per cent in value. This increase was probably due to the construction of war-time cantonments, military highways and railroads, and other war necessities. Ordinary building operations were much less in 1917 than in 1916.

Moulding and building sands made up 64.0 per cent of the sand production; moulding 32.7, building 31.3 per cent. There was a marked falling off of the production of railroad ballast, decreasing from 41.58 in 1916 to 2.66 per cent in 1917.

The following tables give a comparison of the production of sand and gravel in 1916 and 1917, and the production, value and kinds of sands in these two years.

Production in short tons of sand and gravel in Alabama in 1916 and 1917.

	SAND		GRAVEL		Total'		Percentage of U. S. total
	Quantity	Value	Quantity	Value	Quantity	Value	
1916	627,577	147,952	99,073	36,264	726,650	184,216	0.62
1917	355,533	139,675	121,145	82,336	476,678	222,011	0.63
Increase or decrease	-272,044	- 8,277	+ 22,072	+46,072	-249,972	+37,795	
Percentage	- 43.2	- 5.59	+ 22.7	+ 126.1	- 34.2	+ 20.3	

Quantity (short tons), value and kind of sand produced in Alabama in 1916 and 1917.

	Moulding Sand		Building Sand		Paving Sand		Engine Sand		Grinding and Polishing Sand		Railroad Ballast Sand and Gravel		Other Sands		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1916	131,312	41,470	220,336	66,989	*	1,741	6,199	*	*	*	259,957	\$82,413	*	*	627,577	147,952
1917	148,355	54,742	157,107	67,277	*	*	*	*	*	*	12,690	3,014	*	*	476,678	222,011
Increase + or Decrease—	+17,043	+13,272	—63,229	+ 288	—	—	—	—	—	—	—247,267	—29,399	—	—	—150,899	+74,059
Percentage +	+ 1.29	+ 32.6	— 27.9	+ 0.43	—	—	—	—	—	—	— 95.3	— 90.7	—	—	— 25.4	+ 50.0

*Concealed because of less than three producers.

STONE.

EUGENE A. SMITH.

ON ACCOUNT of the variety of uses to which stone is put, there is no regular unit of measurement, and the figures in this report represent the values of the different varieties.

PRODUCTION.

Alabama produces only three kinds of stone, viz., limestone, marble and sandstone.

The total value of the stone produced in Alabama shows an increase in 1917 of 34.0 per cent. The greater part of this increase was in the limestone, (rough and dressed building stone, and furnace flux). There was a notable decrease in the sandstone, while the production of marble showed 16 per cent increase in value. Alabama ranked fourth among the marble-producing states in 1917, whereas it ranked seventh in 1916.

Exact figures for marble, however, cannot be given as there were in 1916 as well as in 1917 only two producers.

The following table gives some additional details of the total stone production.

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1916 and 1917. Percentage of total U. S. value, rank of State and number of plants.

Year	Total Value	Percentage of total U. S. value	Number of Plants	Rank of State
1916	\$1,202,256	1.52	25	20
1917	1,611,497	1.96	29	19
Increase in 1917	409,241	—	—	—
Percentage	34.0	—	—	—

LIMESTONE.

The most important use of limestone produced in Alabama in 1917 as in 1916, was for furnace flux, while

crushed stone for concrete follows next in importance. For the other uses given in the table the value of the limestone shows a decrease, notably in the case of riprap.

The limestone burned into lime or used in the manufacture of Portland cement is not taken into account here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited the total value of the limestone produced in 1917, was \$1,278,908, as compared with \$917,559 in 1916, an increase of \$361,349 or 39.6 per cent.

The value of the limestone produced in Alabama in 1916 and 1917 classified according to the uses of the stone is given in the following table:

Value of limestone (not including marble) produced in Alabama in 1916 and 1917, according to uses.

USES	1916	1917	Increase or Dec'se	Percent.
Rough building _____	\$13,067	*		
Dressed building _____	29,597			
Riprap _____	17,969	4,052	\$-13,917	- 81.2
Crushed Stone:				
Road making _____	1,198	14,170	+ 12,972	+ 1083.0
Railroad ballast _____	.180			
Concrete _____	41,321	54,368	+ 13,047	+ 31.7
Flux _____	807,344	1,159,035	+351,691	+ 43.6
Agricultural _____	4,656	8,428	+ 3,772	+ 81.9
Other _____	2,227	*		

LIMESTONE FOR BUILDING PURPOSES.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the Subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood, in Franklin County, operated by Foster and Creighton Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the University

of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses the quality of cheapness, it can be cut to any design required, and it is at the same time strong and durable.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

The above statements are confirmed by a report on the comparative tests made on the Rockwood stone, and those from Bedford, Ind., and Bowling Green, Ky., by Prof. Robert H. McNeilly, in the Engineering Laboratory of Vanderbilt University.

From this report I give the following extracts:

"GENERAL CHARACTERISTICS.—The Rockwood limestone is an almost pure oolitic limestone with frequent

small crystals of calcite distributed throughout its mass. It resembles closely the Bedford stone in appearance, except that it has a slightly more open texture. The Bowling Green stone is finer in grain, softer and more easily pulverized than either the Bedford or Rockwood stones, and contains an appreciable amount of petroleum, which lends somewhat to the ease with which it is worked. In all three stones the texture is exceptionally uniform, as it is almost impossible to detect the bedding planes by eye; however in this respect the Bowling Green stone is most marked, and it is frequently necessary to test by hammer to detect which is the bed plane. Rockwood stone is lighter in color than either the Bedford or Bowling Green stones.

"CHEMICAL ANALYSIS.—The following is an analysis of the Rockwood stone made at my request by Dr. Paul C. Bowers, Chief Chemist of the Tennessee Geological Department:

	Rockwood Stone.
Moisture and loss on heating to 175° C.....	0.07
Insoluble siliceous residue (SiO ₂ , etc.).....	0.49
Oxide of Iron and Alumina (Fe ₂ O ₃ & Al ₂ O ₃).....	0.30
Carbonate of Lime (CaCO ₃).....	98.23
Carbonate of Magnesia (MgCO ₃).....	0.97
Total.....	100.06

"PHYSICAL TESTS.—Comparative physical tests of the three samples of stone were made as follows:

Loss in weight on drying,
 Cross bending tests,
 Compression tests,
 Absorption tests,
 Per cent. of water absorbed,
 Specific gravity in bulk, and of pulverized stone,
 Density,
 Abrasion tests.

The results of these physical tests are summarized in the CONCLUSIONS below quoted:

"CONCLUSIONS.—The above tests were made as nearly as possible, under identical conditions, and barring the accidental characteristics of the samples, which were selected at random, these results are believed to represent truly the comparative characteristics of each of the stones under consideration.

"The Rockwood stone shows itself to be a superior building stone to others in every respect except density—but even here, since its absorption of water is the lowest of the three, it should prove more durable, while the smaller weight per cubic foot can be placed more cheaply on account of freight charges.

"As compared with the Bowling Green stone, the Rockwood shows a decidedly higher strength, and characteristics which indicate a greater durability. The Bowling Green stone, however, is undoubtedly more easily worked than either of the other two stones, due to its being softer and also to the presence of oil. This oil has the bad effect of staining the stone itself and the contiguous masonry for several years after it is placed, while the very ease with which the stone can be worked makes the Bowling Green very inferior where used for door sills and steps. This is shown well by the Abrasion Test which shows the Rockwood stone in its best light, as a very superior material, for steps, door sills, and other places subject to wear.

"From my examination of these three stones, I believe no builder would make a mistake in using any one of the three, for they are all unquestionably very superior building stones. While each stone may have advantages over the other for some specially desired characteristics, as a building stone for general purposes, each is highly satisfactory.

Respectfully submitted,

ROBERT H. MCNEILLEY,
*Assistant Professor of Civil
Engineering, Vanderbilt University."*

MARBLE.

The marble of Alabama is of two kinds, crystalline, or true marble, and non-crystalline.

The crystalline or statuary marble occurs mainly in a narrow valley along the western border of the metamorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble

as a rule is from one-quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, Bowie's near Rendalia, and Taylor's and McKenzie's near Taylor's Mill, east of Talladega. From all of these marble was quarried before the civil war.

During 1917 two companies reported production of marble in Alabama, viz., the Alabama Marble Company at Gantt's Quarry and the Moretti-Harrah Company, whose quarry adjoins that of the Alabama Marble Company at Gantt's. The other quarries mentioned are in Talladega County, near Sylacauga.

The plant of the Alabama Marble Company at Gantt's Quarry which was completely destroyed by fire in December, 1910, has been rebuilt and equipped with all the machinery needed for the working up of any kind of finished product.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carrara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 200 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

The Moretti-Harrah Company furnishes the marble in blocks for monumental and rough interior purposes.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cam-

brian formation, occurs in Shelby County, a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also at Pratt's Ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Aniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

SANDSTONE.

The returns to the U. S. Geological Survey office show a decrease in the total value of the sandstone produced in 1917, of \$3,897 or 18.55 per cent, as compared with the 1916 production.

By far the greater part of the sandstone produced in 1917 was ganister.

The following table will show the limestone and sandstone production of Alabama from 1912 to 1917 inclusive:

Value of limestone and sandstone production in Alabama, 1912-1917.

KIND	1912	1913	1914	1915	1916	1917
Limestone	\$531,085	\$812,664	\$787,214	\$426,266	\$917,559	\$1,278,908
Sandstone	27,596	151,111	161,773	30,432	20,995	17,098

SUMMARY.

BECAUSE of the difference in units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since in many cases, as for instance coal and coke, and iron and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product and would give an erroneous result.

As the Survey has not, however, the figures upon which to base an estimate of the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State as here given will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1917 raw materials and immediately derived products was \$158,127,150, as compared with \$94,987,229 in 1916: an increase of \$63,139,921 or 66.47 per cent.

The production may be classified as follows:

Raw products	65,423,224
Pig iron	64,309,714
Coke	28,394,212
Total	158,127,150

The more important minerals and products after coal, pig iron and coke, are iron ores, clay products, stone, cement, sand and gravel, and lime given in the order of their relative importance.

Below is a tabular presentation of the value of the mineral products of Alabama, as estimated above for the years 1911, 1912, 1913, 1914, 1915, 1916 and 1917:

Year	Value
1911	\$ 52,772,951
1912	60,141,793
1913	67,530,089
1914	56,769,559
1915	61,791,958
1916	94,987,229
1917	158,008,952

